A COMPARISON OF THE STANDARD AND COMMERCIAL METHODS OF CREAM TESTING

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THESIS

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by

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INTRODUCTION

Since the establishment of the creamery and the cream station there has been a need for investigation of what constitutes an adequate and efficient method for cream testing. This is especially true under the present cream station system, where the majority of cream testers, while good technicians, are not technically trained for the work. This is of importance in considering that there are approximately 2500 cream testers in Michigan.

Fat being the most variable and valuable ingredient of cream, it is only logical that all commercial transactions relative to cream should be based upon the fat content. It was this that gave the incentive to a number of agricultural chemists thirty years ago to devise a simple, rapid and accurate method for the determination of fat, which could be intelligently used by those who either had no training in chemistry or could not obtain access to a chemical laboratory.

The method now in common use is the one given free to the public in 1890 by Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station with the exceptional modification at present of using 9 gram instead of 18 gram samples. Details are discussed in the subject matter of this thesis.

OBJECT OF THE WORK

The principal object in undertaking this work was to determine the varying percentages of errors of commercial methods of cream testing.

The plan employed in determining this error was in conducting personal investigations in creameries and cream stations, making and recording observations of the actual methods in use, and duplicating as nearly as possible the observed methods in the laboratory.

Investigations have proved that unnecessary mistakes are often wilfully or otherwise made by the licensed operator of the cream test.

Such investigations are of value in showing the inadequacy of some of the common commercial practices.

HISTORICAL REVIEW OF LITERATURE

A brief review of literature is hereby presented as a proper setting for the subject matter and experimental work of this thesis. In no way has the writer attempted to make an exhaustive review of the same - only the necessary points of connection of past and present methods of testing are given for a better understanding of the discussion.

Necessity for a butter fat test

In the early days of associated dairying, nearly all of the creameries in the country were conducted upon the gathered cream system. No discrimination was made as to the richness of cream, the patrons receiving pay in proportion to the number of inches or gauges of cream supplied, an inch or gauge being 113 cubic inches. On the average it was calculated that an inch of cream would yield 1# of butter. While it was recognized that some creams would yield more than this and others less, no practical method for measuring the butter-producing capacity of cream had been devised.

The pooling system also opened the way to fraud. If the milk at the factory was bought on the basis of weight alone, the unscrupulous patron could obtain an undue advantage over the factory association by watering his milk or skiming off a portion of the cream.

The pooling system also caused just as much trouble for the owners of non-cooperative factories causing a check on the development of the butter making industry. It was at this juncture of affairs that those interested in the development of associated dairying saw the absolute necessity for devising some simple, practical means of measuring the percent of butterfat.

Forerunners of the Babcock test

The first successful attempt in this direction was made by Messrs. Schock and Bolander of Orangeville, Illinois, who invented a series of test churns in which a number of small samples of cream could be churned at the same time, the yield of butter in these small samples being taken as a measure of the value of cream.

There is reason to believe that this test would

have been extensively used in creameries had not the more convenient "oil test" been introduced about this time. Like the Shock and Bolander churn, the oil test was designed to show the churnable fat of the milk or cream or its equivalent in butter, and not the total fat. The principle of the test is as follows: A known volume of the cream to be tested is placed in a glass tube which it fills about half full. The tube is securely fastened in a machine by which it may be shaken lengthwise at a rapid rate until the butter comes. The tube is next placed in hot water until the butter melts and the fat collects at the top when it may be measured with a special scale which gives directly the number of pounds of butter per creamery inch of cream corresponding to the observed depth of oil in the tube. The average per cent of fat recovered by the oil test varied considerably in duplicate tests and did not as a rule agree closely with that recovered by the large churn. It was found, however, that the melted oil separated by the oil test contained a small quantity of water which increased its volume so that the results by measurement came nearer the

truth than those by weight. The results as a whole showed that although the oil test could not make strictly accurate distinction between the different qualities of cream, it was capable of discriminating between good and poor cream.

Neither of the tests described are satisfactory when applied to milk and consequently are not available in whole milk creameries or in chesse factories.

The need for a more accurate test which could be used for milk as well as cream was apparent so that the Director of the Wisconsin Experiment Station detailed Mr. F. C. Short, assistant chemist, to work along this line. His method estimated the fat in milk. The principle of the test is as follows: The test bottles used were made to contain from 50 cc to 60 cc up to the neck, which was graduated to show the per cent of fat in milk tested. The milk was heated in these bottles in a warm bath, with strong alkali until the fat was saponified and the casein and other constituents of the milk were dissolved. The dark colored solution which resulted was acidified with strong acid and the bottles kept hot in the water bath until the insoluble fatty acids separated in a clear

layer. The bottles were next filled with hot water in order to bring the separated fat into the graduated neck when it could be measured. The method could be applied by anyone who had the patience to complete the test carefully. It gave accurate results with milks containing more than one half per cent of fat, but was not reliable when applied to closely skimmed milks, buttermilk or whey. The test was used to a considerable extent by dairy men and breeders for the selection of cows and was adopted in a few creameries for determining the value of milk from different patrons. Its use however was limited, but served as a stimulus to working experimenters.

Several other methods were worked out between 1888-90, that were named for their inventors, namely, Parson's, Failure and Willard's, Cochran's, and Patrick's tests. In nearly all of these tests, the fat was separated by heating the milk with acids or alkalies to dissolve the solids not fat; and the melted fat was either separated by gravity, or dissolved in ether or gasoline and measured on a percentage scale. These tests all gave fairly accurate results

for whole milk or cream, but were not very satisfactory for factory by products as skim milk or butter milk, although they were put into operation in a number of creameries and served as a basis of payment, they were too complicated and not accurate enough to give complete satisfaction.

Invention of the Babcock Fat Test

At the request of Dean Henry, Dr. Babcock took up the problem to see if further improvements might be made. He developed a number of different methods which worked fairly well, but as they did not seem to be of universal application, were discarded and no publication was made.

One of these tests is of special importance, since it shows the final steps in the development of the Babcock test. In this method, the milk was made strongly alkaline and ether added. The separation of the ethereal solution of fat was facilitated by the use of a centrifugal machine, after which the ether was evaporated and the fat measured. The whole operation was conducted without transfer in bottles similar to those

now used in the Babcock test. At first the ether was evaporated by gradually warming the bottles in a water bath, but it was necessary to do this slowly, and this demanded constant attention to avoid loss of fat by frothing of the liquid. It was found, however that the ether could be completely driven off in a short time without any frothing, if the bottles were heated by a jet of steam, while being slowly revolved in the centrifuge. The bottles were afterwards filled with hot water to bring the separated fat into the graduated neck where it was measured. The method was accurate and applicable to the estimation of fat in whole milk, cream, skim milk, buttermilk and whey.

Many satisfactory tests were made by this method with mixed milks and with milks from individual cows, all of which were satisfactory except in the case of milk from one cow (Sylvia) of the Station herd. The results obtained with the milk of this cow, a Jersey of good size and normal in every particular, did not check with the detailed gravimetric chemical method of analysis.

It was urged upon Dr. Babcock that this case was

exceptional and ought not prevent the publication of the method, since it would be used chiefly for testing mixed milk with which satisfactory results were always obtained. He opposed the recommendation of any method for general use with which he could not secure correct results from every cow in the Station herd. Thus, Sylvia, while temporarily checking results, became the deciding factor in bringing about such modifications of the test as to make its application universal.

Many attempts were made to overcome the difficulty by use of other reagents. Finally it was found that when sufficient concentrated sulphuric acid was added to the milk to dissolve the precipitate that first forms, and ether afterwards added, the test being completed as before, that all of the fat could be recovered in every case. Later, it appeared that equally accurate results could be obtained by increasing the quantity of sulphuric acid and omitting the ether. The acid rendered soluble all solids not fat, while the heat evolved in the mixture melted the fat, allowing it to rise to the surface. When such a mixture was subjected to moderate centrifugal force, the

fat was gathered in a narrow graduated neck of the containing bottle when the per cent of butter fat could be immediately determined by inspection. This method was applicable not only to whole milk and cream but equally so to all of the by products of the factory.

Modified in this way the test is the one sent from the Wisconsin Experiment Station in 1890, known as the Babcock test.

It is worthy of note that so completely was every detail worked out before it was placed in the hands of the public that no change has been made in the essential features of the test. The method of measuring the milk, the volume of the sampling pipette, the character of the test bottle and the technique of the operation remain today the same as left Dr. Babcock's hands in 1890. The mechanical make up of the apparatus has of course been improved.

REVIEW OF EXPERIMENTAL WORK IN LITERATURE

The following is a brief summary of the experimental work on cream testing as found in literature. The writer has searched through the Experiment Station Records, dairy text books and has consulted bulletins which would have direct connection with the experimental work of this thesis. The writer has not attempted to recopy all the experimental work on cream testing.

The review of the past experimental work is given with the view of giving as comprehensively as possible the nature of the experiments conducted. Some conclusions to these tables are recorded.

It is necessary to state in this connection that no similar experimental work as to tables worked out have been found in literature or appeared in any similar form.

Siegmund and Craig (1) state the following: "The Babcock test suggests itself at this time as a subject of investigation. We recognized the limitations of its precision when testing high fat creams but on the other hand when testing partially churned

samples its accuracy representing the fat content of entire consignments as compared with the extraction method appeared to be much greater."

"Accordingly, a number of comparative tests were conducted. It was decided to use a 24 bottle steam driven Babcock machine with a speed of about 800 revolutions per minute; a 36 bottle electrically driven machine with a speed of about 1000 revolutions per minute and to compare results with those of the extraction method. By employing only homogenous samples it was possible to use the results obtained by the extraction method as a standard. In the following comparisons we were careful to select only those results in which duplicate determinations by this method checked closely."

"The Babcock tests were also made in duplicate, employing an accurately weighed 9 gram sample. After first diluting the 9 gram sample with an equal volume of water the usual procedure for carrying out this test was followed." Comparative results are as follows:

Table I. Comparison of Extraction Method with the Electric and Steam Babcock Machine Tests.

Number	Extraction method	Electric Babcock Machine	Steam Babcock Machine
1	36.60	37.20	38.40
2	40.61	40.70	42.00
3	36.75	39.40	39.20
4	43.84	45.60	45.20
5	36.32	36.40	37.00

"It was interesting to note from these figures that although in no case did the three methods check there was nevertheless a characteristic relationship between them. The figures of the extraction method were invariably lower than those by either Babcock process, and the electrically driven machine gave results which were, as a whole, lower than the steam driven machine."

"A review of the text book and other publications upon this subject indicated that with machines of our type a minimum speed of about 200 to 800 revolutions

per minute was essential to accurate results while directions regarding the maximum speed were rather indefinite, about 1200 revolutions per minute being the highest speed that was noted. Upon the assumption that the greater centrifugal force possessed by the electric machine did have some influence upon the fat column, further comparative tests were made at a speed of 1200 revolutions per minute." The results of these tests may be tabulated as follows:

Table II. Comparison of Extraction Method with Electric Babcock Machine Test as effected by Supercentrifuging.

Number	Extraction Method	Electric Babcock Machine
1	38.54	38.80
2	43.49	44.40
3	38.38	39.30
4	34.60	34.80
5	37.73	38.10
6	36.58	37.30

"By comparison with the first series of tests it was found that the average variation under the increased speed had dropped from 1% to about .6% which quite clearly demonstrated that the additional centrifugal force alone was the responsible agent in effecting the change in variation of results."

"Our findings lead us to the opinion, which we believe has not been previously expressed, that any speed above that minimum necessary to bring all the fat to the top exerts a correcting influence upon the length of the fat column."

"A final series of experiments were conducted with a view of determining this point. A Babcock super-centrifuge operated at a speed of 1600 revolutions per minute was used."

The following comparative results were obtained.

Table III. Final Comparative Results of Extraction Method and Electric Babcock Machine Tests as effected by Supercentrifuging.

Number	Extraction Method	Electric Babcock Machine
1	33.50	33.60
2	45.18	45.20
3	40.83	40.80
4	39.12	39.20
5	37.49	37.40

"The difference in the average of the above results is .01 percent, while the greatest single variation is .10 percent."

"From the foregoing experiments with the Babcock method as applied to cream testing we believe that we have brought out a new conception of the purpose of centrifugal force, in demonstrating that by applying sufficient centrifugal force in the operation of the Babcock method for cream testing, it is a relatively easy matter to produce results which compare favorably with those of the ether extraction method."

Guthrie (2) summarized the following:

Table IV. The Effect of Widely Varying Temperatures on Sampling Cream.

Number of Determinations	Average Temperature of cold cream	Average Temperature of warm cream	Average Test of Cold cream	Average Test of Warm Cream
			Percent	Percent
83	56.5°F	85.5°F	30.66	30.86

"these figures show that the test of warm cream is slightly higher than that of the cold."

"Scoville also published data on sampling cream that stood twenty-four hours. This was always sour, fairly cool, and was quite thick. The following is a summary of his figures."

Table V. A Comparison of Sampling Cream after Standing Twenty-four Hours.

Number of Determinations	Average Test of Cream Taken with McKay Tube Before Stirring	Average Test of Cream Taken with McKay Tube After Stirring	Average Test of Cream Taken with Dipper After Stirring
	Percent	Percent	Percent
35	41.69	41.55	41.88

These tables show that there is a very little difference in the test of the cream, whether thoroughly agitated, partially mixed or not stirred at all. The latter table also shows that there is very little difference in the test of the cream when the sampling is made with a McKay sampling tube."

" Scoville also found that there is very little difference in the amount of fat in the cream when sampled individually or compositely. The following

table shows the results of his work. Each composite sample was composed of portions taken from two to six cans of cream.

Table VI. A Comparison of Individual and Composite Sampling of Cream.

Number of Composite Samples	Number of Individual Samples	Composite Sample	Individual Sample
		Pounds Fat	Pounds Fat
20	83	3,183.50	3,169.71

This table shows a difference of 13.79 pounds of fat during the twenty days or a little over .4 percent of the entire amount of fat in favor of the patrons. This is the opposite of what Lee and Hepburn found, for, according to Lee's readings, the composite fell below the daily test .27 percent and, according to Hepburn, the composite samples showed .16 percent less fat than in the daily sample."

A summary of Kunziker's (3) work on cream testing.

Table III. Showing effect of testing two weeks old composite samples.

Table IV. Effect of improperly kept composite samples on creamery receiving 20,000 pounds of fat during month of July.

Table V. Showing effect of storing warm cream samples in various types of sample bottles and at different temperatures.

Table VII. Amount of Acid and Temperature of Acid and Cream.

	Amount of Acid	
	Max.	Min.
Cream testing 50% fat-18 gr.	13.0 cc	8.0 cc
" " " " 9 "	7.5 cc	4.5 cc
" " 28.5 " 18 "	15.0 cc	11.0 cc
" " " " 9 "	8.0 cc	5.0 cc

Where cream and acid are at room temperature, about 70°F, a good test can be obtained by using acid with a specific gravity of 1.83 in amounts not to exceed the above limits.

Ninety six tests with cream and acid at temperatures ranging from 40 - 110°F showed no visible

changes in the percent of fat and the clearness of the test, where the amount of acid used was governed by the color of the mixture - where the amount of acid was not regulated by the color of the mixture, but where the same amount of acid was used at all temperatures, the resulting tests varied widely. In case of cream and acid at 40°F, it required more shaking to affect complete action of the acid on the cream, but the tests were clear and percent fat correct. In the case of cream and acid at 100°F or above, the tests were very dark and charred.

Table VI. Experiments to determine the effect of one and two additions of water on clearness and accuracy of the test.

The average of the tests with two additions of water practically agreed with the gravimetric fat estimation. The average of the tests with one addition of water was .17 percent higher than the gravimetric fat estimation.

Table VII. Showing effect of speed of tester on accuracy of test.

A reduction of speed from 1000 to 400 r. p. m. caused a decrease in the test of .34% fat.

Table VIII. Showing impurities contained in fat column of the Babcock test and resulting error in reading the test.

The percent fat ranged from 98.15 to 98.94, averaging 98.62. The percent of impurities varied from 1.06 to 1.85, averaging 1.38 percent, and the error in the reading of the test due to these impurities fluctuated between .28 and .81 percent, averaging .52%.

Table IX. Showing effect of amount of acid used on the percent of impurities of the fat column and on the resulting error or reading.

Where 14 cc acid were used, the impurities rose to 20.67 percent, with a consequent error of reading of 6.68 percent.

Table X. Showing effect of degree of moisture and heat in tester on the percent of impurities of the fat column and resulting error of reading.

Table XI. Showing percent of residual fat in twenty-six cream tests.

About four-fifths of the liquid fat were found in the liquid portion and one-fifth of the residual fat adhered to the glass of the test bottles. The

total residual fat fluctuated between .229 and .38 percent, averaging .28 percent.

Table XII. Showing effect of richness of cream, style of test bottle and size of charge on percent of residual fat.

There seems to be a tendency toward a slightly higher percent of residual fat in tests with a 9 gram charge than with an 18 gram charge, but the difference between the two is not great enough to be of much consequence.

Table XIII. Showing effect of condition of cream on percent of residual fat.

The condition of the cream has no noticeable effect on percent of residual fat. Differences between sweet and sour cream were no greater than the variations between different samples of the same cream.

Table XIV. Showing effect of speed of tester on percent of residual fat.

The speed of the tester exerts a marked influence on percent residual fat.

Table XV. Showing percent of volatile fatty acids lost in the Babcock test and resulting error of reading.

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Table VI. Length of time necessary for fat to reach same temperature as water in both.

Table VII. Temperature of liquid in different parts of Babcock test bottle.

Table VIII. Effect of using glymol in reading the fat column in a Babcock cream test bottle.

The data show that the addition of glymol lowers the reading of the fat column in the short neck bottles 1.5 per cent, and in the long neck bottles the fat column is reduced but 1 percent. Since the reading on the short neck bottles is .5 percent higher than the reading on the long neck bottles, the same results are obtained.

Table IX. The chemical method compared with the Babcock method - ether being used as a fat extractor. The meniscus was reduced by adding glymol and fat column read at 150°F.

DESCRIPTION OF APPARATUS

Specifications for standard apparatus and chemicals for testing cream for butterfat by the Babcock test.

Two types of bottles shall be accepted as standard cream test bottles in Michigan.

Cream Test Bottle 1: 50 per cent 9 gram short neck cream test bottle, graduated to .5 per cent. Graduation - the total percent graduation shall be 50. The graduated portion of the neck shall have a length of not less than 2½ inches (63.5 mm). The graduation shall represent 5 percent, 1 percent and .5 percent.

The maximum error in the total graduation or in any part thereof shall not exceed the volume of the smallest unit of the graduation.

Neck - The neck shall be cylindrical and of uniform internal diameter throughout. The cylindrical part of the neck shall extend at least 5 mm. below the lowest and above the highest graduation mark. The top of the neck shall be flared to a diameter of not less than 10 mm. The charge of the bottle shall be 9 grs. All bottles shall bear on top of the neck

above the graduations, in plainly legible characters, a mark defining the weight of the charge to be used - (9grs.).

Bulb - The capacity of the bulb up to the junction of the neck shall not be less than 45 cc. The shape may be either cylindrical or conical with the smallest diameter at the bottom.

The total height of the bottle shall be between 5 7/8 and 6 1/2 inches.

Cream Test Bottle 2: 50 per cent 9 gr. long neck cream test bottle, graduated to .5 percent. The same specifications in every detail as specified for the 50 per cent 9 gr. short neck bottle shall apply for the long neck bottle, except that the total height shall be between 8½ and 9 inches, and that the maximum error in the total graduation or in any part thereof shall not exceed 50 percent of the volume of the smallest unit of the graduation.

Pipette - 9 cc pipettes are commonly used, but since cream is weighed in place of measured, detailed specifications of the pipette are not necessary.

Acid measure - Capacity 17.5 cc. Though varying amounts of acid are used, depending upon the

method used in testing, a 17.5 cc acid measure is very convenient. This may be a simple glass cylinder graduated to deliver 17.5 cc. A convenient little device is the small glass dipper, by which the proper quantity of acid may be dipped out of a larger container and poured into the test bottle. Capacity using 8.8 cc.

Centrifuges - Hand and power centrifuges either steam or electrical are used, varying in size and bottle capacity as factory conditions require. They all consist mainly of a horizontal revolving disk or wheel provided with swinging sockets to hold the bottles. At rest these sockets allow the bottles to stand upright, but when in motion the centrifugal force causes the sockets to swing outward, bringing the bottles to a horizontal position with the necks toward the center.

Calipers or Dividers - Used for measuring the fat column. Readings are accelerated by using calipers with a stiff hinge.

Water bath for cream samples: Should be conveniently arranged for regulating and recording proper temperature of samples.

Water bath for test bottles - Should be of sufficient size with necessary equipment to maintain a constant temperature of 135°F - 140°F.

Cream testing scales - Several types of balances designed for weighing cream charges are on the market. The small torsion balances prove to be very satisfactory if care is taken that the important metal parts are not allowed to rust.

In Michigan cream test scales must comply with the following specifications:

1. The scales shall be provided with a graduated face of at least ten divisions over which the pointer shall play.

2. The pointer must reach to the graduated divisions and shall terminate in a fine point to enable the readings to be made clearly and distinctly.

3. The clear interval between the divisions on the graduated face shall not be less than five one hundredths inch.

4. All scales whose weight indications are changed by an amount greater than one half the tolerance allowed, when set in any position on a surface

making an angle of three degrees or approximately five percent with the horizontal shall be equipped with leveling screws and a device which will indicate when the scale is level, provided, that the scale shall be rebalanced at zero each time its position is altered during the test.

5. The addition of one half grain (30 milligrams) to the scale when loaded to capacity shall cause a movement of the pointer at least equal to one division on the graduated face.

6. The sensibility reciprocal and tolerance of cream test and butterfat test scales shall be one half grain (30 milligrams).

Manipulation of Balance :

1. Level the balance each time before using.

2. Adjust or balance the instrument immediately before weighing and make sure that its beam swings freely and does not stick.

3. Protect the balance from air currents. The setting of the balance in a box large enough for convenient operation and with the near side open is recommended.

4. Use accurate weights only and be sure they are clean.

5. Release the balance slowly and easily. Careless and rough handling may damage spring bands and dull knife edges.

6. Do not use the balance when out of repair.

Weights - 9 gram weights for 9 gram cream test bottles, preferably stamped correct by the U.S. or State Bureau of Standards.

Specifications for standard 9 gram weights.

1. Weights shall be of brass or aluminum.

2. Weights shall have smooth surfaces and no sharp points or corners.

3. Weights shall not be covered with a soft or thick coat of paint or varnish.

4. All weights shall be clearly marked with their nominal value, i.e. 9 for nine gram weights.

5. The tolerance shall be forty milligrams for nine gram weights and fifty milligrams for eighteen gram weights.

Chemicals -

1. Commercial sulphuric acid, specific gravity 1.82 - 1.83.

2. Glymol - a while mineral oil of high grade, with specific gravity less than that of butterfat, usually colored red with an aniline dye to facilitate reading the test.

THE PRINCIPLE OF THE BABCOCK TEST

The Babcock Test is a method for the accurate and rapid determination of butterfat in milk and milk products, such as cream, buttermilk, skimmilk, butter, cheese, etc.

On account of its accuracy it has been adopted in many states as the official method of determining the fat in milk and cream.

The principle of the test is as follows:

1. Based on the use of sulphuric acid.
2. Based on centrifugal force.

Eighteen grams of the substance to be tested (as 17.6 cc of milk, skim milk, etc.) is put into a glass bottle with a long graduated neck. To this is added 17.5 cc of sulphuric acid. The test is based on the fact that strong sulphuric acid (sp. gr. 1.82 - 1.83) will dissolve all non-fatty solid constituents of milk and other dairy products. (Sulphuric acid is preferable to other mineral acids on account of its affinity to water. When mixed with milk, the mixture heats greatly, thus keeping the fat in liquid form without the application of artificial heat.)

When the acid is mixed with the milk it turns dark colored, due to the effect of the sulphuric acid on the nitrogenous constituents and sugar in the milk. The acid also increases the specific gravity of the mixture. The fat is then separated from the acid solution by whirling the bottle and its contents in a centrifugal machine, usually for eight minutes. Two additions of hot water are finally added to bring the separated fat into the graduated neck. After removing the meniscus by adding a few drops of alymol, the percentage of fat is read directly from the graduations.

Making the test

Securing the cream sample: It is very important that the small quantity of cream taken for the test must be truly representative. The percentage of fat in the cream in one part of the can when it is received may be very different from that in another part. There is a tendency for the richer cream to rise to the top, for lumps to form in the souring of the cream, and there is likely to be a considerable amount of heavy cream sticking to the sides of the can. The

object therefore of thoroly mixing the cream before the sample is taken is to cause every portion of it to be alike in fat content, so that any sample taken out will be the same in fat content as any other sample. To accomplish this the cream must be thoroly stirred, giving it a boiling motion. The sides and shoulder of the can should be carefully scraped and the scrapings well mixed with the other portions of cream before sampling.

Composite samples: Cream being thick, viscous and rich in fat it is difficult to secure an accurate sample of it and almost impossible to secure a representative composite sample from a number of cans. For these reasons composite sampling of cream is not permitted.

Preparation of sample: Cream samples which are not lumpy or too thick require no other preparation than thorough mixing previous to weighing.

When frozen or churned cream is received the adequate method of sampling is to first warm it slowly to make it more fluid and to melt the

globules of butter. In the case of churned cream warming must be gradual and should not exceed 100°F. This will prevent "oiling off".

Very thick, heavy cream should be warmed to 85°F or 90°F. then poured carefully and weighed out at once.

Weighing the sample: When bottles are placed on or removed from the scale, the scale should always be locked. All manipulations of the pans should be accomplished through the locking device and not by touching the pans.

A sensitive balance is used for weighing out the cream. One 9 gr. 50% cream test bottle is balanced on the scale, the latter should be placed on a level and solid table. After balancing the bottle, a 9 gram weight is placed on the opposite scale pan, and by means of a pipette enough cream is let into the test bottle to balance the weight. The correct amount of cream by weight is nine grams.

Why cream is weighed in place of measured: Since the specific gravity of cream is lower than that of milk, (sp. gr. of milk 1.032, that of cream (40%= .9908) a 17.6 cc pipette will not deliver 18 grs.

of cream, or 9 cc pipette - 9 grs. cream, and the result will be too low.

Bacterial activity not only increases the acidity of the cream but produces gas bubbles which are held in suspension and decrease the specific gravity of cream.

The determination is further complicated by the varying viscosity of cream. If cream has a high viscosity an appreciable amount will adhere to the glass of the pipette and as air bubbles are generally present in cream and tend to rise slowly, the real amount of cream falls short of the desired weight.

Correctness of fat determinations in cream can only be obtained by weighing.

Mixing with acid: The amount of acid added will vary from 10 - 12 cc, depending on the richness of the cream, the strength of acid, and the temperature of the cream and the acid. The richer the cream and the higher the temperature, the less acid is required.

The following paragraph discusses the amount

of acid commonly used in the three standard methods adopted.

If 9 grams of cream are used, about 9 cc of acid is added or enough to turn the sample to a chocolate brown within a few seconds. By holding the test bottle in a slanting position and slowly rotating it, the acid can be added in such a way that it will flow down the side of the neck and wash any cream sticking to the neck down into the bottle.

Methods adopted as standard

Three methods of performing the test have been adopted as standard methods, each of which insures accurate results.

Method I. - (1) Add standard commercial sulphuric acid until the mixture of acid and cream, immediately after shaking, resembles in color coffee with cream in it. Usually about 8 - 12 cc of acid is required in the case of the 9 gram bottle, the amount needed depending on the temperature of acid and cream and on the richness of the cream.

(2) Whirl in standard centrifuge at proper speed, five, two and one minutes, respectively, filling the bottles with hot, soft water, temperature 140°F or above, to the bottom of the neck after the first whirling and to near the top graduation after the second whirling.

Method II. - (1) Add 9 cc of water after the cream has been weighed into the test bottle and before the acid is added, then add 17.5 cc acid and proceed as in previous method. This method is applicable with the 9 gram bottle only.

(2) Same as in Method I.

Method III.- (1) Add 8 - 12 cc of acid in the case of the 9 gram bottle until the mixture of cream and acid, after shaking, has a chocolate brown color. After the cream and acid have been thoroly mixed and all lumps have completely disappeared, add a few cubic centimeters (not less than 5 cc) of hot, soft water, whirl five minutes, add hot, soft water to near the top of scale and whirl one minute.

(2) Proper speed of the centrifuge is 800 revolutions per minute for an 18 inch diameter wheel and 1000 revolutions per minute for a 12 inch diameter wheel.

Centrifuging - After the addition and mixing of the acid, the test bottles are placed in the centrifuge and whirled. It is important that the required speed be always kept up. Care as to proper speed is essential as the results obtained by too slow whirling may seem to be all right, often obtaining a clear separation of fat and good duplicates, even when the fat is not completely separated.

Reading the test - Flatten the meniscus by placing a few drops of glymol upon the fat column. This facilitates the reading. The test bottles are placed in a water bath at 135°F - 140°F for three minutes prior to reading.

Using a calipers, the test is read by measuring from the lower to the upper extremity of the fat column.

Appearance of fat column - When the test is made properly the fat column is clear, i.e. free from curdy or charred material, translucent, has a golden yellow or amber color and the top and bottom lines are sharply defined. The liquid below the fat column is also clear and no curdy or charred material is found at the top of the liquid, or at the junction of the liquid and fat column.

PRELIMINARY EXPERIMENTAL WORK

Purpose of experimental work: The experimental work was to study the increased or decreased efficiency of commercial methods, with the accompanying causes for the same. Since most commercial methods have a lower efficiency than the standard method, the remedies for the causes of the lower efficiency were studied, and results tabulated in table form, with the object, importance of experiment, results and conclusions of each experiment worked.

The experimental part is divided into:

Preliminary investigational work in which the methods and practices of commercial cream testing were observed and data recorded, with commenting notes on their methods. This work was carried on from November 19, 1921 to March 4, 1922. Most investigations were made on Saturday, which was usually the busiest day of the week at most cream stations. Cream testing methods were consequently observed when perhaps they would be most apt to be varied.

Applied experimental work where each commercial method was compared with the standard method as to

its efficiency, followed by experimental work which exposes the error in certain commercial practices of cream testing. This part is supplemented with tables, with the object, results of experimental work and conclusions of each table.

In no case have predetermined results been considered.

Explanatory note - Duplication in laboratory of observed commercial methods were made as carefully as possible, however, methods observed then may be quite different from the ones the licensed operators now perform. At most stations observations were made without having the operator aware of it. This was done to get at first hand the operator's method of testing. The writer vouches for the methods observed under specific dates, but does not guarantee that the methods now are the same. This is accounted for by the more rigid enforcement of the State laws at present in regard to cream testing.

The general neatness and care of the operators

in conducting the test is commendable in most all cases. Most operators were good practical technicians and their methods of technique cannot be severely criticized.

Observations of commercial methods

Sampling: The care with which samples were taken varied with the amount of work the operators were obliged to do. Most observations were made on Saturday, generally the busiest day during the week. Only in a few cases was sampling so rapidly done that a question might be raised as to whether it was truly representative of the contents of the full can of cream. Most samples, however, were rather hurriedly taken but which could be called good representative samples. In a few cases extra care and precaution were taken to secure the most representative sample possible.

Preparation of samples: Generally the cream samples were weighed without any preliminary preparation. A few operators were very careful and warmed the samples prior to weighing, getting the cream in more fluid form and free from lumps. Even though

observations were made in the winter no frozen cream samples were seen taken.

Weighing the sample - Weighing was well done in all cases. Bottles were carefully balanced previous to adding the 9 grs. cream. Torsion balances weighing single samples were most generally used.

Mixing with acid - The acid used was of good color and was purchased by the operator for testing purposes.

The acid and cream were shaken together in the test bottle until a chocolate color appeared. The action of the acid was then checked by the use of warm or hot water.

Table VIII. The Approximate Varying Amounts of Acid used in Testing at each Cream Station or Creamery.

No. of cream station	Am't. acid c.c.	No. of cream station	Am't. acid c.c.	No. of cream station	Am't. acid c.c.
1	9	9	9	17	17.5
2	17-19	10	9	18	9
3	9-12	11	9	19	17.5
4	20	12	17.5	21	15.0
5	9	13	9	22	17.5
6	9	14	17.5	23	9
7	9	15	17.5	24	9
8	9	16	8.8	25	9

Addition of water - The amounts of warm or hot water used to check the action of the acid varied with the amounts of acid used. Large quantities of water were used where larger amounts of acid were added. Generally from 5 - 10 cc of warm or hot water were used before the centrifuging.

Centrifuging - Number of minutes.

There is quite a variation in number of times the test bottles were whirled and the length of time for each whirling. In most cases the proper speed was maintained regardless of the kind of centrifuge used. The following table gives the number of times the test bottles were centrifuged, the minutes of each whirling, and the total number of minutes.

Table IX. Centrifuging Table.

Cream Station	Centrifuging	No. of times	Total minutes
1	4 - 3	2	7
2	(2-3)-(1-2)	2	3-5
3	(3-6)-(½-1)	2	5½-7
4	4 -(2-3)	2	6-7
5	5 -(1-1½)	2	6-6½
6	(3-5)- ½	2	3½-5½
7	5 - 3	2	8
8	5 -(2½-3)	2	7½-8
9	5 - 3	2	8
10	5 - 3	2	8
11	5 - 2	2	7
12	4 -(1-1½)	2	5-5½
13	5 - 3	2	8
14	4 - 1	2	5
15	30-25 turns	2	-
16	5-2-1	3	8
17	(2-3)-(2-3)	2	4-6
18	5-2-1	3	8
19	5-3	2	8
21	3-1	2	4
22	3-1	2	4
23	2-3	2	5
24	3-1	2	4
25	5-2	2	7

Kind of centrifuges used - For experimental purposes the type of centrifuge used was noted and duplication of work in laboratory was carried on by the use of similar centrifuges. The accompanying table gives the bottle capacity and type of centrifuge used.

Table X. Bottle capacity and type of centrifuge used.

Cream Station	Bottle Capacity	Type of Centrifuge
1	8	Electrical
2	12	"
3	12	"
4	8	"
5	8	"
6	8	"
7	8	"
8	12	"
9	8	Hand
10	24	Steam
11	8	Electrical
12	7	Hand
13	12	"
14	10	"
15	8	"
16	48	Steam
17	24	"
18	24	Electrical
19	12	"
21	20	Steam
22	12	Electrical
23	12	"
24	12	"
25	12	"

Use of water bath for test bottles: Commercial operators can be rightly criticized for not having a convenient and proper temperature water bath in which the test bottles should be placed previous to reading the test. Only two of the twenty-four operators used

a water bath prior to reading the test, five operators took the bottles from steam centrifuges, while the remaining fourteen read the test as the bottles were taken from cold centrifuges. A later table, No. 7, shows the effect of using a proper temperature water bath upon the percent butterfat.

Reading the test - Use of glymol. The correct percent of butterfat cannot be accurately determined without the use of glymol, a light mineral oil usually colored red to facilitate the reading. The glymol, called by operators "red reader," flattens the meniscus, so the fat column can be measured from the straight line on top to the straight line on the bottom. Five operators did not use glymol, one used it occasionally, while the other eighteen used it in reading all the tests.

Appearances of fat columns - The appearance of the fat column is dependent upon the methods used in making the test. Where the tests were properly made the appearance of the column was of a clear, transparent, golden yellow, and free from curdy or charred material. Where too much or too little acid was used,

too cold or too warm a temperature of cream and acid too slow speed of the centrifuge or too low temperature during centrifuging, the fat column would vary in appearance, containing curdy (undigested casein) or charred material, or being too dark or too light in color. Causes of abnormal appearance of the fat column will be found in the accompanying table.

Table XI. Causes of abnormal appearances of fat columns.

Fat column too light in color or containing white particles of undigested casein.	Fat column to dark in color or containing black particles or charred material	Foam on surface of fat column
Not enough acid	Too much acid	Use of hard water
Acid too weak	Acid too strong	
Temperature of cream and acid too low prior to mixing	Temperature of cream and acid too high prior to mixing	
Centrifuging at low temperature	Not enough water added to check action of acid	
Mixing not continued long enough to dissolve all serum solids	Mixing of acid and cream interrupted before solution was complete	
	Acid and cream allowed to stand too long in test bottle before being mixed	

Table XII. Remedies for abnormal appearances of fat columns.

Fat column too light in color or containing white particles of undigested casein	Fat column too dark in color or containing black particles or charred material	Foam on surface of fat column
Use proper amounts of acid which is dependent on method used in testing	Use proper amounts of acid which is dependent on method used in testing	Use soft water
Use acid of correct strength and specific gravity (1.82-1.83)	Use acid of correct strength and specific gravity (1.82-1.83)	Hard water to which a few drops of sulphuric acid is added can be used.
Keep the temperature of the cream and acid at 45° - 70°F before mixing	Do not have temperature higher than 45° -70°F previous to mixing.	Pure rain water or condensed steam can also be used satisfactorily.
Mix cream and acid thoroughly before centrifuging	Do not allow acid and cream to stand too long in the test bottle prior to mixing.	
Use a warm centrifuge if possible.	Add a small amount of warm water to test bottle to check the action of the acid after the proper color has been obtained previous to centrifuging.	

Table XIII. Summarized table of commercial methods of testing.

No. of cream station	Amount of acid c.c.	Approximate amounts of water c.c.	Centrifuging minutes				Water bath	Reader	Centrifuge	
			1st	2nd	3rd	Total			Bottle capacity	Type of centrifuge
1	9	10	4	3		7	No	Yes	8	Elec.
2	17-19	5-10	2-3	1-2		3-4	"	"	12	"
3	9-12	5	5-6	½-1		5½-7	"	"	12	"
4	20	10	4	2-3		6-9	"	"	8	"
5	9	8	5	1-1½		6-6½	"	"	8	"
6	9	8-10	3-5	½		5½-5	"	"	8	"
7	9	5-9	5	3		8	"	"	8	"
8	9	6-8	5	2½-3		7½-8	Yes	"	12	"
9	9	5-9	5	3		8	No	"	8	Hand
10	9	10	5	3		8	"	"	24	Steam
11	9	8-10	5	2		7	"	"	8	Elec.
12	17.5	7-10	4	1-1½		5-5½	"	"	7	Hand
13	9	8-9	5	3		8	"	"	12	"
14	17.5	7-10	4	1		5	"	No	10	"
15	11.5	6-10	30 turns	25		-	"	"	8	"
16	8.8	2-3	5	2	1	8	"	Yes	48	Steam
17	17.5	6-10	2-3	2-3		4-6	"	No	24	"
18	9	2-3	5	2	1	8	Warmed by steam	Commonly used	24	Elec.
19	17.5	5-9	5	3		8	Yes	Yes	12	"
21	15	5-9	3	1		4	No	No	20	Steam
22	17.5	6-10	3	1		4	"	Yes	12	Elec.
23	9	5	2	3		5	No	No	12	"
24	9	5	3	1		4	"	Yes	12	"
25	9	3-5	5	2		7	"	"	12	"

Criticisms of commercial methods

Composite cream samples - One licensed operator made a daily practice of taking composite cream samples and testing them every fifteen days. He had been informed that such a practice could not be recommended for cream samples, but insisted he obtained satisfactory results and had no reason to change. When a can of cream was received it was thoroughly stirred with a disc shaped stir rod, then a small V shaped or cone shaped dipper was lowered into the cream and a sample of the cream taken. If the can of cream was full i.e. if it was a ten gallon can, a full dipper of the cream was taken out and placed in a rubber stoppered sampling jar. If the ten gallong can was only half filled or partially filled a half dipper of cream was taken out. The composite samples were preserved until tested by using a corrosive sublimate tablet. The composite samples were thoroughly mixed previous to weighing out nine grams of cream for the butterfat test.

As previously stated composite samples of milk

may be taken and tested without any appreciable error or inaccuracy due to the more uniform specific gravity of the milk. But since the specific gravity of the cream will vary, due to its varying degrees of richness, and because of its viscosity and air bubbles contained in it, cream under no circumstances should be tested by the use of composite samples.

Weighing lumpy cream samples - One of the common criticisms that can be given to commercial methods is weighing lumpy cream into the test bottles. Very few of the station operators took the pains to warm the cream samples, or crush the lumps prior to weighing. This results in incorrect testing.

There are several reasons why lumps occur in cream. One reason is mixing warm cream, which is usually freshly separated, with cold cream without properly stirring after dumping together. This is one of the most common causes of lumpy cream as stated by cream station operators. Another cause of lumpy cream is mixing very old and thick cream

which is commonly sour with new cream or freshly separated cream, which is generally sweet. Much of the cream which arrives at cream stations and creameries is found lumpy. Weighing lumps of cream into a test bottle to be tested results in inaccurate testing.

Before lumpy cream is weighed out the cream should be warmed, the lumps crushed or strained from the cream, later remixed with the cream, so that no lumps appear while the cream flows into the test bottle, previous to mixing with acid.

Omitting the use of red reader - Another common criticism which can rightly be given to the operators of cream stations is their light consideration concerning the use of glymol. As previously stated glymol or red reader is a light mineral oil, usually colored red to facilitate reading, a few drops of which are placed on the surface of the fat column to destroy or flatten the meniscus.

Why the meniscus is destroyed in the reading of cream tests. In the reading of milk tests, the meniscus is read to compensate for the loss of

residual fat in the testing.

In the reading of cream tests, the meniscus is not read, because the amount of moisture and acid in the fat column compensates for any loss of residual fat lost during the testing.

To prevent a higher reading of the percent of butterfat, the meniscus is eliminated by using a little glymol.

One cause of station shortages can be traced to the omission of red reader, which causes a higher reading in percent of butterfat than is actually present.

Table XXIII gives a comparison of the use and non use of red reader.

Reading tests without previous lowering test bottles into proper temperature water bath. Another direct cause of station shortages is due to the varying temperatures at which the percent of butterfat is read in the test bottles. The centrifuges in the cream stations have access to direct cold air draughts from open windows or doors or are located next to heat

ed stoves or boilers, thus affecting the temperature of the test. In most cases the test bottles were taken from cold or unheated centrifuges and read without warming. In a few cases the test bottles were taken from steam testers. Since pure butterfat has the correct expansion coefficient at 140°F, tests should be read at this temperature. If read below this temperature the percent of butterfat will be low, if read higher than this temperature, the percent will be too high.

Table XXI shows the effect of reading tests at varying temperatures.

Abnormal appearances of fat column - Abnormal appearances of the fat column were common observations. Carelessness in the use of acid is the important cause. Regardless of the abnormal appearances of the fat column the tests were read, the same as if it were a correct appearance. The writer has observed fat columns charred black on the one extreme and being entirely white and curdy on the other extreme, with a varying amount of black and

white particles in many others. Station operators do not generally regard the appearance of the fat column of any importance as a factor of correctness in reading the percent fat.

Table XII gives the remedies for abnormal appearing fat columns.

Improper centrifuging - The speed of the machine, the number of times the test bottles were whirled, the total minutes of centrifuging are factors considered under the above heading. A hurriedness to complete the test to give the waiting farmer his check lies back of improper centrifuging. It is a common practice among station operators to abbreviate the length of time and number of times the test bottles are whirled. Quite a number of operators feel as if the main thing is to get the fat in the neck of the bottle and do it as quickly as possible. They all seem to get what they go after irrespective of results.

Table XIX shows the effect of proper and improper centrifuging upon varying percentages of cream samples.

Varying temperatures of cream and acid prior to mixing. Cream samples are taken from cans that may be cool, while others are comparatively warm. Most cream is weighed into a test bottle without previous preparations. Consequently the cream, prior to the addition of acid, generally has a range of temperatures. The acid used was generally kept at room temperature. Some operators had the acid bottles placed near small oil heaters, others had them placed so they would be subject to cold droughts. Consequently the acid had ranging temperatures. Few operators know what the correct temperature of either acid or cream should be previous to mixing together.

Table XVII shows the effect of ranging temperatures of acid and cream upon the percent and appearance of the fat column.

Following is the applied experimental work where each commercial method was compared with the standard method as to its efficiency. This is followed by experimental work which exposes the error in certain commercial practices of cream testing. This part is supplemented with tables, with the object, results and conclusions of each experiment.

Method II, as discussed under "Methods adapted as standard", was used as the standard method.

Table XIV. A comparison of the standard and commercial methods of cream testing.

Standard		Cream Station			Comparisons +		Comparison -		Percent above or below standard	Remarks
Samples tested	Test of cream	No. of	samples tested	Test of cream	Total No.	% Difference	Total No.	% Difference		
4	24.5	12	12	24.0	12	.5	0	0	-.5	No water bath used
4	33.0	14	17	33.6	0	0	17	.6	+.6	No red reader used. No water bath
4	37.5	15	15	38.4	0	0	15	1.1	+ 1.1	Improper centrifuging. No red reader. No water bath
4	42.0	13	12	41.3	13	.7	0	0	-.7	No water bath
4	33.3	9	14	32.8	14	.5	0	0	-.5	No water bath
4	31.5	1	11	31.0	11	.5	0	0	-.5	No water bath
4	28.0	2	14	28.6	0	0	14	1.2	+ 1.2	No water bath abnormal fat column. Improper centrifuging
4	32.3	3	18	31.6	0	0	18	.7	+.7	No water bath Abnormal fat column
4	47.5	4	15	46.9	15	.6	0	0	-.6	No water bath
4	30.0	11	15	29.3	15	.7	0	0	-.7	No water bath Abnormal fat column
4	28.0	19	15	28.0					OK	

Table XIV. Continued

Standard		Cream Stations			+ Comparisons		- Comparisons		Percent above or below Standard	Remarks
Samples tested	Test of cream	No. of	Samples tested	Test of cream	Total No.	Difference	Total No.	Difference		
4	33.5	22	15	32.8	15	.7	0	0	-.7	No. water bath. Abnormal fat column
3	40.5	25	15	40.2	15	.3	0	0	-.3	No red reader
3	39.5	25	15	39.0	15	.5	0	0	-.5	No water bath
3	21.0	17	15	20.5	15	.5	0	0	-.5	No water bath
3	19.5	10	15	19.1	15	.4	0	0	-.4	No water bath
4	19.0	18	14	18.7	14	.3	0	0	-.3	No water bath No red reader
3	35.0	20	15	34.5	15	.5	0	0	-.5	No water bath
3	28.0	21	15	27.6	15	.4	0	0	-.4	No red reader No water bath
3	30.0	5	15	29.5	15	.5	0	0	-.5	No water bath
3	40.5	24	15	40.0	15	.5	0	0	-.5	No water bath
3	39.5	8	15	39.5					OK	
3	24.0	7	15	23.5	15	.5	0	0	-.5	No water bath
3	28.5	6	15	27.9	15	.6	0	0	-.6	No water bath Red reader commonly used

Discussion of Table XIV.

Summarizing tabulated comparisons of standard and commercial methods.

Total no.of cream stations.	Total no. + comparisons	Ave. of B.F. of + comparisons	Total no. - comparisons	Ave. of B.F. of - comparisons	Comparative efficiency, based on highest B.F. and satisfactory appearance of fat column	
					Standard	Commercial
24	18	.51	4	.90	91.63%	8.33%

Two of the commercial methods which were considered O.K. were not figured in the efficiency percentage for the standard method since they closely correlated with the standard test.

Method of obtaining percent efficiency for standard and commercial methods -

Twenty-four cream stations were investigated. Duplication of cream testing methods in twenty-two stations gave results in favor of the standard method - ($\frac{22 \times 100}{24}$ = 91.63% efficiency). The methods used in two stations gave identical results with the standard

($\frac{2 \times 100}{24}$ = 8.33%) which equals the efficiency for commercial methods.

+ comparisons indicated the percentage of butterfat below the standard test and are recorded as tests in favor of the standard.

- comparisons indicate the percentage of butterfat above the standard test and are recorded as tests inferior to the standard.

From the above figures it is noted that eighteen of the commercial methods produced a lower percentage of butterfat averaging .01%. Generally, this is accounted for in omitting the use of a proper temperatured water bath for the test bottles previous to reading which in most cases would be the correction factor for the lower readings.

It is also noted that four commercial methods, produced a higher percentage of butterfat averaging .9%. This may be properly accounted for in omitting the use of a proper temperatured water bath, improper centrifusing, abnormal appearances of the fat column and omitting the use of Zylrol.

Conclusion - The higher efficiency of the standard method is unquestionable. It is therefore recommended for obtaining the best possible tests as a commercial practice. Later tables and experiments will give causes and results of the lower efficiency of most commercial methods.

Table XV. Effect of ranging temperatures of acid on the percent butter fat and on the appearance of the fat column. (Temperature of cream constant 60°F - 70°F.)

Steam Centrifuge

Acid temperature	Test of cream	Test % adding 9 c.c. water prior to adding 17.5cc acid	Average of variation	Appearance of fat column	Test adding 17.5cc acid direct to cream	Average % variation	Appearance of fat column	No. of trials
40°F	31.5	31.7	.2	Not OK 1.2	31.5	.1	Not OK 1.2	5
	30.0	30.0	none	Not OK 1.2	30.1	.1	Not OK 2	5
	37.5	37.0	.5	Not OK 1.2	37.1	.1	Not OK 2	5
45°F	31.5	31.7	.2	Not OK 1.2	31.5	None	OK	5
	30.0	30.0	none	Not OK 1.2	30.0	None	OK	5
	37.5	37.0	.5	Not OK 1.2	37.5	None	OK	5
50°F	34.0	34.1	.1	Not OK 1.2	34.0	None	OK	5
	30.0	30.0	none	OK	30.0	None	OK	5
	37.5	37.2	.3	Not OK 1.2	37.5	None	OK	5
60°F	19.5	19.5	none	Not OK 1.2	19.5	None	OK	12
	31.5	31.5	none	OK	31.5	None	OK	12
	37.5	37.3	.2	Not OK 1.2	37.5	None	OK	12
70°F	19.5	19.5	none	OK	19.5	None	OK	5
	29.5	29.5	none	OK	29.5	None	OK	5
	37.5	37.5	none	OK	37.5	None	OK	5

Table XV continued

Steam centrifuge

Acid temperature	Test of cream	Test % adding 9 c.c. water prior to adding 17.5 cc. acid	Average of variation	Appearance of fat column	Test adding 9cc acid direct to cream	Average % variation	Appearance of fat column	No. of trials.
60°F	19.5	19.5	None	OK	19.5	None	OK	5
	31.0	31.0	None	OK	31.0	None	OK	5
	37.5	37.5	None	OK	37.5	None	OK	5
90°F	19.5	19.5	None	OK	19.2	.3	Not OK 5	5
	31.5	31.5	None	OK	31.0	.5	Not OK 5.4	5
	37.5	37.5	None	OK	36.8	.7	Not OK 5.4	5
100°F	19.5	19.5	None	OK	19.1	.4	Not OK 5.4	5
	30.5	30.5	None	OK	30.0	.5	Not OK 5.4	5
	37.5	37.5	None	OK	37.0	.5	Not OK 5.4	5
110°F	19.5	19.5	None	OK	19.5	.3	Not OK 5.4	5
	31.5	31.5	None	OK	31.0	.5	Not OK 5.4	5
	37.5	37.5	None	OK	36.5	1.0	Not OK 5.4	5

Table XV. Continued

Steam Centrifuge

Acid temperature	Test of cream	Test % adding 9 c.c. water prior to adding 17.5 cc. acid	Average % of variation	Appearance of fat column	Test adding 9cc acid direct to cream	Average % variation	Appearance of fat column	No. of trials
120°F	19.5	19.5	None	OK	19.0	.5	Not OK 3,4	5
	31.5	31.5	None	OK	31.0	.5	Not OK 3,4	5
	41.5	41.5	None	OK		charred black		5
130°F	19.5	19.5	None	OK		charred black		5
	31.0	31.0	None	OK		charred black		5
	41.5	41.5	None	OK		charred black		5
140°F	24.0	24.2	.2	Not OK 3,4		charred black		5
	30.0	30.2	.2	Not OK 3,4		charred black		5
	41.5	42.0	.5	Not OK 3,4		charred black		5

Key - 1. Color too light - grayish white to pale yellow - not clear
2. Some curdy material in fat column or at base of fat column
3. Color too dark - dark brown, brownish black, black brown
4. Some charred material in fat column or at base of fat column
5. Charred black

Discussion of Table XV.

Object - To determine the effect of ranging temperatures of acid on the percent butterfat and on the appearance of the fat column, having the temperature of the cream constant 60-70°F.

Importance - Acid bottles were kept in various places at cream stations which would affect the temperature of the acid. Some acid bottles were placed near heated stoves and boilers, others were placed where the prevailing atmosphere temperatures throughout the year would affect the acid temperature. To determine therefore the proper temperature limits of the acid would aid in accounting for the abnormal appearances of the fat column which would effect the butterfat percentages.

Method of procedure -

1. Cream samples testing 20%, 30% and 40% or nearly so, were used as a basis of comparison.

2. Single 9 gram samples of cream were weighed for the most accurate results.

3. The weighed 9 gram cream samples were maintained at a constant temperature of 60°F-70°F.

4. The temperature of the acid was obtained by placing the acid bottles and flasks in a water bath, the desired temperature brought about by the use of steam or ice water.

5. The 9 c.c. water added to the cream samples was at the same temperature as the cream samples - 60°F - 70°F. Water of higher or lower temperatures would partially offset the acid temperatures.

6. To each of five test bottles containing 9 grams of cream, 9 c.c. of water (60°-70°F) was added and then 17.5 c.c. acid. To each of five other test bottles containing 9 grams of cream, 9 c.c. of acid was added. The acid added was immediately shaken thoroughly with the cream and the test bottles centrifuged before any appreciable cooling took place.

7. The tests were completed by the standard method.

8. The standard method of testing was used

except as to the modifications as pertain to this experiment. By the standard method is meant centrifuging 5-2-1 minutes at proper speed, adding hot water to the base of the neck after the first five minutes whirling, adding hot water to raise the fat into the graduated portion of the neck after the second two minutes whirling, clarifying the fat column by a third whirling of one minute, lowering test bottles into a proper temperature water bath 135°F-140°F for three minutes previous to reading the percent, placing a few drops of glymol on the surface of the fat column to flatten the meniscus, and measuring the percentage with calipers.

Results - The following facts are considered under results:

1. The average percent variation of butterfat due to acid of ranging temperatures. This is considered under two headings.

(a) Percent of butterfat adding 9 c.c. water (60-70°F) prior to adding 17.5 c.c. acid.

Acid temperatures of 40°F, 45°F, 50°F and 60°F

are too low for correct appearances of the fat column and correct fat percentages. At low temperatures the color of the fat column ranges from a clear, grayish white to pale yellow, besides containing such foreign material as light gray colored curdy material either in the fat column or at the bases of it.

Acid temperatures of 70°F, 80°F, 90°F, 100°F, 110°F, 120°F and 130°F are satisfactory as to correct fat column appearances and percentages. There is a tendency, however, for the fat columns to range from darker yellow to browns as the acid temperature is raised from 100°F to 130°F.

Acid temperatures of 140°F or above are too high and affect the butterfat percentages as well as the fat column appearances due mostly to the presence of charred particles.

Fat percentages are affected by the amounts of foreign material, either curdy or charred, present in the fat column. This amount will vary and so cause changes in percentages generally from 1.1 to .5 percent

either below or above the correct percentage for temperatures of 40oF to 50°F, and above temperatures of 140°F.

Fat columns were considered OK when careful readings with calipers did not detect any difference in percent.

Fat columns were considered OK which were clear in color. Color ranges from a dandelion yellow to light brown were considered as acceptable and satisfactory, provided the color was clear.

(b) Percent of butterfat adding 9 c.c. acid direct to 9 grams of cream.

Acid temperatures of 40°F or below are too low for correct fat column appearances. There is a slight variation in percentages also.

Acid temperatures of 45°F, 50°F, 60°F, 70°F and 80°F are satisfactory for percentages and normal appearances.

Acid temperatures of 90°F, 100°F, 110° and 120°F are too high. Fat percentages varied considerably along with abnormal fat column appearances

due to charred material, the percent varying from .2 to 1.0 percent.

Acid temperatures of 120°F, 130°F and 140°F resulted in completely charred fat columns.

2. The appearance of the fat column - The appearance of the fat column was noted in every case since a correct appearance correlates with acid of proper temperature, while an abnormal appearance indicates acid of too high or too low a temperature.

Comparison of Results - Comparison of results adding 9 c.c. water (60-70°F) and 17.5 c.c. acid and adding 9 c.c. acid direct to cream.

	O.K. Temperatures
9 c.c. water and 17.5 c.c. acid	70°F, 80°F, 90°F, 100°F, 110°F, 120°F, 130°F
9 c.c. acid	45°F, 50°F, 60°F, 70°F, 80°F

The comparison shows that at low acid temperatures of 40°F, 45°F and 60°F, results are not satisfactory, using 17.5 c.c. acid with 9 c.c. water. However, acid temperatures from 70°F to 130°F are satisfactory.

When 9 c.c. acid was added directly low acid temperatures from 45°F to 80°F, are preferable for best results. Acid temperatures above 80°F are not suitable for proper results.

Conclusion - Since the acid temperature at cream stations is apt to be between 75°F and 90°F, rather than from 45°F to 80°F, it is recommended that the addition of 9 c.c. water (60°-70°F) and 17.5 c.c. acid be used for testing cream of unknown fat content.

Water permits greater range of higher acid temperatures without charring, and results are more satisfactory and not so uncertain of obtaining.

Table XVI. Effect of ranging temperatures of cream on the percent butterfat and on the appearance of the fat column. (Temperature of acid constant 60°F - 70°F.)

Steam Centrifuge

Cream temperature	% Cream	% Adding 9cc. water prior to adding 17.5 cc acid	Average of variation	Appearance of fat column	% adding 9cc acid direct to cream	Average of variation	Appearance of fat column	No. of trials
32°F	23.5	23.4	.1	Not OK 1,2	23.3	.2	Not OK 1,2	5
	28.0	28.1	.1	Not OK 1,2	28.0	none	Not OK 1,2	5
	40.5	40.7	.2	Not OK 1,2	40.5	none	Not OK 1	5
40°F	21.5	21.5	none	Not OK 1,2	21.5	none	OK	5
	28.0	28.0	none	Not OK 1	28.0	none	OK	5
	40.5	40.5	none	Not OK 1	40.5	none	OK	5
50°F	21.5	21.5	none	OK	21.5	none	OK	5
	28.0	28.0	none	OK	28.0	none	OK	5
	40.5	40.5	none	OK	40.5	none	OK	5
60°F	21.5	21.5	none	OK	21.5	None	OK	5
	28.0	28.0	none	OK	28.0	none	OK	5
	41.5	41.5	none	OK	41.5	none	OK	5

Table XVI. Continued

Steam Centrifuge

Cream temperature	% cream	% Adding 9 cc. water prior to adding 17.5 cc. acid	Average of variation	Appearance of fat column	% adding 9 cc acid direct to cream	Average of variation	Appearance of fat column	No. of trials
	21.5	21.5	none	OK	21.5	none	OK	5
70°F	28.0	28.0	none	OK	28.0	none	OK	5
	41.5	41.5	none	OK	41.5	none	OK	5
	22.5	22.5	none	OK	22.0	.5	Not OK 3	5
80°F	30.2	30.2	none	OK	30.4	.2	Not OK 3,4	5
	41.5	41.5	none	OK	42.0	.5	Not OK 3	5
	23.0	23.0	none	OK	22.2	.2	Not OK 3,4	5
90°F	30.2	30.2	none	OK	30.7	.5	Not OK 3,4	5
	41.5	41.5	none	OK	42.0	.5	Not OK 3,4	5
	23.0	23.0	none	OK	22.0	1.0	Not OK 3,4	5
100°F	30.2	30.2	none	Not OK 3	30.5	.3	Not OK 3,4	5
	41.5	41.5	none	OK	42.5	1.0	Not OK 3,4	5

Table XVI. continued.

Steam centrifuge

Cream temperature	% Cream	% Adding 9 cc. water prior to adding 17.5 cc. acid	Average of variation	Appearance of fat column	% adding 9 cc. acid direct to cream	Average of variation	Appearance of fat column	No. of trials
110°F	21.5	21.5	None	Not OK 5	21.7	.2	Not OK 5	5
	30.2	30.0	2	Not OK 5	30.4	.2	Not OK 5	5
	41.5	41.5	none	Not OK 3,4	42.0	1.5	Not OK 5	5
120°F	21.5	22.0	.5	Not OK 3,4	22.0	5	Not OK 5	5
	28.0	28.6	.6	Not OK 3,4	29.0	1.0	Not OK 5	5
	41.5	42.0	.5	Not OK 3,4	42.7	1.2	Not OK 5	5

Key - 1. Color too light - grayish white to pale yellow - not clear
2. Some curdy material in fat column or at base of fat column
3. Color too dark - dark brown, brownish black, black brown
4. Some charred material in fat column or at base of fat column
5. Charred black

Discussion of Table XVI.

Object: To determine the effect of ranging temperatures of cream on the percent butterfat and on the appearance of the fat column, having the temperature of the acid constant 60°F-70°F.

Importance - Very few of the licensed operators of cream stations took special care to have the temperature of the cream constant previous to the addition of the acid. Since the cream patrons do not always store the cream in cool places previous to delivery or take special precautions of maintaining a low temperature of the cream enroute, the cream would have varying temperatures when it arrived at the cream station. To determine the proper temperature limits of the cream would therefore aid in accounting for the inaccuracies of commercial methods of cream testing.

Method of procedure -

1. Cream samples testing 20%, 30% and 40% or nearly so were used as a basis of comparison.

2. Single 9 gram samples of cream were weighed for the most accurate results.

3. The acid used was at a constant temperature of 68-70°F.

4. The 9 c.c. of water used was at the same temperature of the cream previous to adding the acid.

5. The varying temperatures of the cream was obtained by placing the test bottles in a water bath, the desired temperature brought about by the use of steam or ice water.

6. To each of five test bottles containing 9 grams of cream at temperatures of 32°F to 120°F 9 c.c. of water, same temperature as the cream, was added, then 17.5 c.c. acid. To each of five other test bottles containing 9 grams of cream at temperatures of 32°F to 120°F, 9 c.c. of acid was added. The acid added was immediately shaken thoroughly with cream and the test bottles centrifuged before any appreciable cooling took place.

7. The tests were completed by the standard method.

8. The standard method of testing was used except as to the modifications as pertain to this experiment.

9. The ranging temperatures of 32°F, 40°F, 50°F and so on to 130°F were used, using 20%, 30% and 40% cream as a basis of comparison.

Results - The following factors are considered under results.

1. The average percent variation of butterfat due to cream of ranging temperatures. This is considered under two headings.

(a) Percent of butterfat adding 9 c.c. water, same temperature as cream, previous to adding 17.5 c.c. acid.

Cream temperatures of 32°F and 50°F or below are too low for correct fat percentages and normal appearances of the fat column. At low temperatures the color of the fat column is lighter, and with various amounts of curdy material present, the butterfat percentage will vary.

Cream temperatures of 50°F, 60°F, 70°F, 80°F and 90°F, can be safely used to accomplish correct testing.

There is also a tendency for the fat columns to become darker in color as the temperature of the cream is raised.

Cream temperatures of 100°F, 110°F and 120°F, or above are too high and cause too much variation in percent and produce abnormal appearing fat columns.

(b) Percent of butterfat adding 9 c.c. acid direct to 9 grams of cream.

Cream temperatures of 32°F, or below are too low for correctness of results.

Cream temperatures of 40°F, 50°F, 60°F and 70°F are suitable for satisfactory testing.

Cream temperatures of 80°F, 90°F and 100°F, or above are too high. The charred material renders the results inaccurate.

Cream temperatures of 110°F and 120°F, resulted in completely charred fat columns.

2. The appearance of the fat column.

The appearance of the fat column was noted in every case since a correct appearance correlates with cream of proper temperature.

3. Dispersion of results - Comparisons of results adding 9 c.c. water (same temperature as cream) and 17.5 c.c. acid and adding 9 c.c. acid direct to cream of varying temperatures.

	C.T. Temperatures
9 c.c. water and 17.5 c.c. acid	40°F, 50°F, 60°F, 70°F, 80°F, 90°F
9 c.c. acid	40°F, 50°F, 60°F, 70°F

Comparisons show that below temperatures of 40°F and above 90°F, results are not acceptable, using 17.5 c.c. acid and 9 c.c. water (same temperature as cream). Cream temperatures from 40°F to 90°F, however, are satisfactory.

When 9 c.c. acid was added directly to the cream, low temperatures are to be preferred for accurate results. Temperatures below 40°F and above 70°F are not satisfactory.

4. Conclusion - The results show that when 9 c.c. water is used with acid, the cream may have a more

extended range of temperatures. It is again recommended (as in Table XV) that the addition of 9 c.c. water (60°F - 70°F) and 17.5 c.c. acid be used for testing cream of unknown fat content. Better results are more certain.

In comparison with Table XV using 9 c.c. water and 17.5 c.c. acid, it is noted that acid temperatures may be higher and have the greater range, as from 70°F to 130°F, while cream temperatures are more limited to low temperatures of 40°F to 90°F, which are considered comparatively low temperatures.

In comparison with Table XV using 9 c.c. acid direct, it is noted that acid temperatures again have the higher and greater range, as from 45°F to 80°F, while cream temperatures are more limited to low temperatures of 40°F to 70°F.

From the above comparisons it is recommended from a testing standpoint that cream patrons maintain as low a temperature of their cream as possible prior to deliver.

Table XVII. Effect of same temperature of both acid and cream on the percent butterfat and on the appearance of the fat column.

Steam Centrifuge

Acid & cream temperature	Am'ts. of acid c.c.	Test of cream 29.5	% variation	Appearance of fat column	Am'ts. of acid c.c.	Test of cream 29.5	% Variation	Appearance of fat column	Am't. of acid c.c.	Test of cream 29.5	% Variation	Appearance of fat column	No. of trials for each test
40°F	8	29.1	.4	Not OK	8	29.7	.2	Not OK	9	29.8	.3	Not OK	3
	9	29.5	none	Not OK	9	29.5	none	OK	10	29.7	.2	Not OK	
	10	29.6	.1	Not OK	10	29.5	none	OK	11	29.7	.2	Not OK	
45°F	8	29.5	none	Not OK	8	29.6	.1	Not OK	9	29.5	None	OK	3
	9	29.5	none	OK	9	29.5	none	OK	10	29.5	none	OK	
	10	29.5	none	OK	10	29.5	none	OK	11	29.6	.1	Not OK	
50°F	8	29.5	none	OK	8	29.5	none	OK	8	29.6	.1	Not OK	3
	9	29.5	none	OK	9	29.5	none	OK	9	29.5	none	OK	
	10	29.5	none	OK	10	29.5	none	OK	10	29.5	none	Not OK	
55°F	8	29.5	none	OK	8	29.5	none	OK	8	29.5	none	OK	3
	9	29.5	none	OK	9	29.5	none	OK	9	29.5	none	OK	
	10	29.5	none	OK	10	29.5	none	OK	10	29.7	.2	Not OK	
60°F	8	29.5	none	OK	8	29.5	none	OK	8	29.5	none	OK	3
	9	29.5	none	OK	9	29.5	none	OK	9	29.5	none	OK	
	10	29.5	none	OK	10	29.5	none	OK	10	29.5	none	Not OK	

Table XVII. Continued

Steam centrifuge

Acid & cream temperature	Am'ts. of acid c.c.	Test of cream 23.5	% Variation	Appearance of fat column	Am'ts. of acid c.c.	Test of cream 29.5	% Variation	Appearance of fat column	Am't. of acid c.c.	Test of cream 29.5	% Variation	Appearance of fat column	No. of trials for each test
	8	23.5	None	OK	8	29.5	none	OK	8	29.5	none	OK	
70°F	9	23.5	None	OK	9	29.5	none	OK	9	29.5	none	OK	3
	10	23.5	None	OK	10	29.6	.1	Not OK	10	29.6	.1	Not OK	
	7	23.5	None	OK	7	29.7	.2	Not OK	6&7	29.5	none	OK	
75°F	8	23.5	None	OK	8	29.5	none	OK	8	29.5	none	OK	3
	9	23.0	.5	Not OK	9	29.7	.2	Not OK	9	29.7	.2	Not OK	
	7	23.5	None	OK	7	29.7	.2	Not OK	6	29.6	.1	Not OK	
80°F	8	23.7	.2	Not OK	8	29.5	none	OK	7&8	29.5	none	OK	3
	9	24.5	1.0	Not OK	9	29.6	.1	Not OK	9	29.7	.2	Not OK	
	7	23.5	none	OK	6	29.5	none	Not OK	5	29.6	.1	Not OK	
85°F	8	23.7	.2	Not OK	7	29.5	none	OK	6&7	29.5	none	OK	3
	9	22.5	1.0	Not OK	8	29.6	.1	Not OK	8	29.6	none	Not OK	
	6	23.5	none	OK	6	29.5	none	OK	5	29.5	none	Not OK	
90°F	7	23.5	none	OK	7	29.5	none	OK	6&7	29.5	none	OK	3
	8	23.7	.2	Not OK	8	29.7	.2	Not OK	8	29.5	none	Not OK	

Table XVII. Continued

Acid & cream temper-ature	Steam centrifuge												
	Am'ts. of acid c.c.	Test of cream 23.5	% Vari-ation	Appear-ance of fat column	Am'ts. of acid c.c.	Test of cream 29.5	% Vari-ation	Appear-ance of fat column	Am't. of acid c.c.	Test of cream 29.5	% Var-ia-tion	Appear-ance of fat column	No. of trials for each test
95°F	6	23.5	none	OK	6	29.5	none	OK	5	29.6	.1	Not OK	3
	7	23.5	none	Not OK	7	29.5	none	OK	6	29.5	none	OK	
	8	23.7	.2	Not OK	8	29.6	.1	Not OK	7	29.5	OK	OK	
100°F	5	23.5	none	OK	6	29.5	none	OK	5	29.7	.2	Not OK	3
	6	23.5	none	OK	7	29.5	none	OK	6	29.5	none	OK	
	7	23.9	.4	Not OK	8	29.7	.2	Not OK	7	29.5	none	OK	
105°F	5	23.5	none	OK	5	29.5	none	OK	5	29.5	none	OK	3
	6	23.5	none	OK	6	29.5	none	OK	6	29.5	none	OK	
	7	23.8	.3	Not OK	7	29.5	none	Not OK	7	29.7	.2	Not OK	
110°F	5	23.7	.2	Not OK	4	29.6	.1	Not OK	4	29.5	none	OK	3
	6	24.0	.5	Not OK	5	29.5	none	OK	5	29.5	none	OK	
	7	23.8	.3	Not OK	6	29.5	none	OK	6	29.7	.2	Not OK	
120°F	5	24.0	.5	Not OK	4	29.4	.1	Not OK	4	29.5	none	OK	3
	6	24.0	.5	Not OK	5	29.5	none	OK	5	29.5	none	OK	
	7	23.8	.5	Not OK	6	29.7	.2	Not OK	6	29.8	.3	Not OK	
130°F	5	24.0	.5	Not OK	4	29.5	none	Not OK	4	29.5	none	OK	3
	6	24.0	.5	Not OK	5	29.5	none	Not OK	5	29.6	.1	Not OK	
	7	23.9	.4	Not OK	6	29.7	.2	Not OK	6	29.7	.2	Not OK	
140°F	5	24.0	.5	Not OK	4	29.7	.2	Not OK	4	29.7	.2	Not OK	3
	6	24.0	.5	Not OK	5	29.8	.3	Not OK	5	29.8	.3	Not OK	
					6	29.7	.2	Not OK	6	29.7	.2	Not OK	

Discussion Table XVII.

Object - To determine the effect of same temperature of both acid and cream on the percent butterfat and on the appearance of the fat column.

Importance - Since stations operators inquired as to the proper temperature limits of both acid and cream previous to mixing, the accompanying experimental data will be of a guiding assistance in securing proper tests.

Method of procedure -

1. The preliminary steps as in Tables 1 and 2 are the same as to the weighing of the cream, using 20%, 30% and 40% cream as a basis of comparison, using a water bath to secure the desired temperatures of both acid and cream and centrifuging after mixing acid with cream.

2. Three (3) cream samples for each temperature for each test of cream was brought to the desired temperature after which acid of the same temperature but of various amounts was added by means of a graduated ten (10 c.c.) pipette.

3. The acid and cream were then thoroughly shaken and immediately placed in the steam centrifuge and whirled.

4. The tests were completed by the standard method of testing as in centrifuging 5-2-1 minutes, addition of hot water after first and second whirlings, placing test bottles in a proper temperatured water bath 135°F - 140°F before reading tests, using glymol and measuring percent with calipers.

5. The standard method of testing was used throughout the experiment except as to the modifications as pertain to this experiment.

Results - The following factors are considered under results:

1. The average percent variation of butterfat due to acid and cream of the same varying temperatures using varying amounts of the acid.

2. The appearance correlates with a proper test.

Discussion of results - The following table records the proper amounts of acid which gave suitable results with ranging temperatures of acid and cream, for 20 %, 30% and 40% cream.

Test of cream	40°F	45°F	50°F	55°F	60°F	70°F	75°F	80°F	85°F
	cc	cc	cc	cc	cc	cc	cc	cc	cc
23.5		9-10	8-10	8-10	8-10	8-10	7-8	7	7
29.5	9-10	9-10	8-10	8-10	8-10	8-9	8	8	7
39.5		9-10	9	8-9	8-9	8-9	8-8	7-8	6-7

90°F	95°F	100°F	105°F	110°F	120°F	130°F	140°F	Proper amounts of acid in cc.'s which gave suitable results
cc	cc	cc	cc	cc	cc	cc	cc	
6-7	6	5-6	5-6					
6-7	6-7	6-7	5-6	5-6	5	5		
6-7	6-7	6-7	5-6	4-5	4-5	4		

The following table records more generally the proper amounts of acid to use, when the cream and acid are at the same temperatures. These determinations are approximately correct to ½ c.c. of acid, as measured by a graduated ten (10) c.c. pipette. This data is applicable to cream testing between twenty (20) percent and forty (40) percent.

	Temperature of acid				
Tests of cream percent	45-70°F	75-80°F	85-100°F	105-110°F	120-130°F
20 to 40	8-10 cc	7-8 cc.	6-7 cc.	5-6 cc.	4-5 cc.

The charts show a definite relation between the amounts of acid used and the temperature of both the acid and cream. At low temperatures of 45°F to 70°F, for example, twice as much acid is used as when the temperature is 120°F to 130°F. One can note also the gradual decrease of acid used as the temperature is increased.

It is to be noted also that often the fat percentage is correct but the appearance of fat column is abnormal, and that the color may be normal with the fat in percent varying slightly.

Conclusion - Temperature of both acid and cream has much to do in securing properly made tests. It is therefore recommended that the temperatures of the cream and acid be low, 45°F - 70°F, rather than high, since a constant amount of 8-10 c.c. acid may be used within such a temperature radius.

This conclusion would seem to apply fairly well at cream stations, where the temperatures of the arriving cream are more apt to vary between 45°F - 70°F, than at higher temperatures.

Table XVIII. Effect of varying temperatures and amounts of water added to cream (65°F-70°F) previous to adding 17.5 cc acid (65°F - 70°F), upon the fat percentage and appearance of the fat column.

Steam Centrifuge

Temperature of water added	Am'ts. of water added cc.	Test of cream 40.5%	% Variation	Appearance of fat column	Am'ts. of water added cc.	Test of cream 20.5%	% Variation	Appearance of fat column	Am'ts. of water added cc.	Test of cream 20.5%	% Variation	Appearance of F.C.	Trial for each test of cream
	6	41.0	.5	Not OK	6	21.0	1.0	Not OK	7	20.5	none	OK	
65°F	8	40.5	none	OK	8	20.0	none	Not OK	8	20.5	none	OK	3
	9	40.5	none	OK	9	20.0	none	OK	9	20.5	none	OK	
	6	41.0	.5	Not OK	6	20.2	.2	Not OK	7	20.5	none	OK	
40°F	8	40.5	none	OK	8	20.0	none	OK	8	20.5	none	OK	3
	9	40.5	none	OK	9	20.0	none	OK	9	20.5	none	OK	
	6	41.0	.5	Not OK	6	20.2	.2	Not OK	7	20.5	none	OK	
50°F	8	40.7	.2	Not OK	8	20.0	none	OK	8	20.5	none	OK	3
	9	40.5	none	OK	9	20.0	none	OK	9	20.5	none	OK	
	7	41.0	.5	Not OK	7	20.0	none	Not OK	7	20.5	none	OK	
60°F	8	40.7	.2	Not OK	8	20.0	none	OK	8	20.5	none	OK	3
	9	40.5	none	OK	9	20.0	none	OK	9	20.5	none	OK	
	7	41.0	.5	Not OK	9	20.0	none	OK	9	20.5	none	OK	
70°F	8	40.6	.1	Not OK	10	20.0	none	OK	10	20.5	none	OK	3
	9	40.5	none	OK	11	20.0	none	OK	11	20.5	none	OK	

Table XVIII. Continued

Steam centrifuge

Temperature of water added	Am'ts. of water added cc.	Test of cream 40.5%	% Variation	Appearance of fat column	Am'ts. of water added cc.	Test of cream 30.0%	% Variation	Appearance of fat column	Am'ts of water added cc.	Test of cream 20.5%	% variation	Appearance of fat column	Trial for each test of cream
80°F	7	41.0	.5	Not OK	9	30.0	none	OK	9	20.5	none	OK	3
	8	40.7	.2	Not OK	10	30.0	none	OK	10	20.5	none	OK	
	9	40.5	none	OK	11	30.0	none	OK	11	20.5	none	OK	
90°F	9	40.5	none	OK	9	30.0	none	OK	9	20.5	none	OK	3
	10	40.5	none	OK	10	30.0	none	OK	10	20.5	none	OK	
	11	40.5	none	OK	11	30.0	none	OK	11	20.5	none	OK	
100°F	9	40.5	none	OK	9	30.0	none	OK	9	20.5	none	OK	3
	10	40.5	none	OK	10	30.0	none	OK	10	20.5	none	OK	
	11	40.5	none	OK	11	30.0	none	OK	11	20.5	none	OK	
110°F	9	40.8	.3	Not OK	9	30.2	.2	Not OK	9	20.7	.2	Not OK	3
	11	40.8	.3	Not OK	12	30.1	.1	OK	12	20.5	none	Not OK	
	12	40.5	none	OK	14	30.0	none	OK	14	20.5	none	OK	
120°F	9	40.8	.3	Not OK	9	30.2	.2	Not OK	9	20.7	.2	Not OK	3
	11	40.8	.3	Not OK	12	30.2	none	OK	12	20.5	none	Not OK	
	12	40.5	none	OK	14	30.0	none	OK	14	20.5	none	Not OK	

Table XVIII. Continued

Steam Centrifuge

Temperature of water added	Am'ts. of water added cc.	Test of cream 40.5%	% Variation	Appearance of fat column	Am'ts. of water added cc.	Test of cream 30.0%	% Variation	Appearance of fat column	Am'ts. of water added cc.	Test of cream 20.5%	% variation	Appearance of fat column	Trials for each test of cream
130°F	9	41.0	.5	Not OK	9	30.2.	.2	Not OK	9	20.8	.3	Not OK	
	11	40.9	.4	Not OK	12	30.0	none	OK	12	20.5	none	Not OK	3
	12	40.5	none	OK	14	30.0	none	OK	14	20.5	none	OK	
140°F	9	41.0	.5	Not OK	9	30.2	.2	Not OK	9	20.7	.2	Not OK	
	11&12	41.0	.5	Not OK	12&14	30.0	none	OK	12	20.7	.2	Not OK	3
	14&16	40.5	none	OK	16	30.0	none	OK	14&16	20.5	none	OK	
150°F	9&12	41.0	.5	Not OK	9&12	30.5	.3	Not OK	9&12	20.8	.3	Not OK	
	14	40.5	none	OK	14	30.0	none	OK	14	20.5	none	OK	3
	16	40.5	none	OK	16	30.0	none	OK	16	20.5	none	OK	
160°F	9&12	40.9	.4	Not OK	9&12	30.2	.2	Not OK	9&12	20.7	.2	Not OK	
	14	40.5	none	OK	14	30.0	none	OK	14	20.5	none	OK	3
	16	40.5	none	OK	16	30.0	none	OK	16	20.5	none	OK	

Discussion of Table XVIII.

Object - To determine the effect of varying temperatures and amounts of water added to cream ($65^{\circ}F$-$70^{\circ}F$) previous to adding 17.5 c.c. acid ($65^{\circ}F$ - $70^{\circ}F$), upon the fat percentage and appearance of the fat column.

Importance - Considerable discussion arises between station operators concerning the temperature and the amount of water to add to the cream previous to adding the acid. Some operators preferred hot water, others lukewarm to cold water.

Method of procedure -

1. The preliminary steps of weighing cream samples, method of adding acid, centrifuging and reading tests are the same as in Table 1, 2 and 3.

2. The standard method of testing was used except as to the modifications as pertain to this experiment.

3. Three (3) cream samples were used for each temperature for each percent of cream.

4. The various amounts of water at different temperatures was added by means of a graduated 10 cc pipette.

5. Immediately after adding the water, the acid was added. This was done at once to determine the actural influence of the water, without having the temperature of the cream exert any appreciable changes upon the temperature of the water added.

6. Acid, water and cream were thoroughly shaken and test bottles centrifuged. Tests were completed using the standard method.

7. 17.5 cc. of acid was added after water of varying temperatures and amounts had been previously mixed with the cream.

Results - The following factors are considered under results:

1. The variation in percent of butterfat due to water of various amounts and temperatures.

2. The appearance of the fat column, since correct appearances correlate with properly made tests.

Discussion of results - The following table records the proper amounts of water at different temperatures which give suitable results, having the acid and cream at a constant temperature of 65°F to 70°F.

Test of cream	35°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F
	cc	cc	cc	cc	cc	cc	cc	cc
20.5	7-9	7-9	7-9	7-9	9-11	9-11	9-11	9-11
30.0	9	8-9	8-9	8-9	9-11	9-11	9-11	9-11
40.5	8-9	9	9	9	9	9	9-11	9-11

Test of cream	110°F	120°F	130°F	140°F	150°F	160°F
	cc	cc	cc	cc	cc	cc
20.5	14	14	14	14-16	14-16	14-16
30.0	12-12	12-14	12-14	14-16	14.-16	14-16
40.5	12	12	12	14.-16	14-16	14-16

The following table summarizes briefly the approximate amounts of water to use at different temperatures. This data is applicable to cream testing twenty (20) to forty (40) percent.

	Temperatures of water		
Test of Cream	35°F - 100°F	110°F-130°F	140°F-160°F
20 to 40 %	9 cc.	12-14 c.c.	14 - 16 c.c.

There exists a definite relation between the temperature of the water and the amount used to secured suitable tests. Less water is used at low temperatures. Much more at high temperatures is used to prevent the rapid action of the acid from burning the fat. Acid action is slower when using water of comparatively low temperatures as from 35°F. to 100°F. The increase in the amount of water used as the temperature increases is readily noted.

Conclusions - The amounts of water to add to cream previous to addition of 17.5 c.c. acid has much todo with its temperature. It is recommended that for securing properly made tests that 9 c.c. of water be used at temperatures from 35°F to 100°F

Using 9 c.c. of water at temperatures of 90°F and 100°F gave the best appearing fat columns, being clearer yellow and freer of foreign material. Temperatures from 85°F to 80°F produced acceptable appearing fat columns, but they were not as clear a yellow and contained small amounts of foreign material in the lower portion.

Table XIX. Effect of length of time of centrifuging on percent butterfat and on the appearance of the fat column.

Centrifuging			Steam Centrifuge						Electrical Centrifuge						No. of trials in each centrifuge
Length of time	Total minutes	No. of times	Richness of cream %		%		%		Richness of cream %		%		%		
			20.5	var.	29.5	var.	39.5	var.	21.0	var.	30.0	var.	38.2	var.	
5-2-1	8	3	20.5	none	29.5	none	39.5	none	21.0	none	30.0	none	38.2	none	4
5-3	8	2	"	"	"	"	"	"	"	"	"	"	"	"	4
5-2	7	2	"	"	"	"	"	"	"	"	"	"	"	"	4
5-1	6	2	"	"	"	"	"	"	"	"	"	"	"	"	4
4-3-1	8	3	"	"	"	"	"	"	"	"	"	"	"	"	4
4-3	7	2	"	"	"	"	"	"	"	"	"	"	"	"	4
4-2	6	2	"	"	"	"	"	"	"	"	"	"	"	"	4
4-1	5	2	"	"	"	"	"	"	Not OK 2		"	"	Not OK 2		4
3-3-1	7	3	"	"	"	"	"	"	Not OK 2		"	"	38.2 None		4
3-4	7	2	"	"	"	"	"	"	Not OK 1,2		"	"	"	"	4
3-3	6	2	"	"4	"	"4	Not OK 2		Not OK 2,4		"	"	Not OK 2,3,1		4
3-2	5	2	"	"4	"	"4	Not OK 2		Not OK 2,3		"	"	Not OK 2,3		4
3-1	4	2	"	"4	"	"4	Not OK 2				Not OK 2,4		Not OK 2,3,1		4
2-2-1	5	3	"	"4	Not OK 4,2						Not OK 2,3,1				4
2-3	5	2	"	"4	Not OK 4,2						Not OK 2,3				4
2-2	4	2	"	"4	Not OK 4,2										
2-1	3	2	"	"4											
1-1	2	2	"	"4											

Key - 1. Abnormal appearance of fat column
2. Not a clear yellow
3. Small amounts of gray white, black or curdy particles.
4. Liquid below fat column not clear

Discussion Table XIX.

Object - To determine the effect of length of time and number of times of centrifuging on percent butterfat and on the appearance of the fat column.

Importance - The number of whirlings and the length of time of each whirling varied with the different station operators. To merely centrifuge long enough to raise the fat into the graduated portion of the neck is not sufficient. Foreign material which often rises with the fat causes slight variations in percentage when centrifuging is not sufficient.

Method of procedure -

1. 9 c.c. warm water and 17.5 c.c. acid was added and thoroly mixed with the cream before tests bottles were centrifuged.

2. Acid and cream were burned to the proper color before placing in centrifuge.

3. Hot water was added to test bottles in both the steam and electrical centrifuges after required whirlings.

4. Steam was turned on during whirlings in the steam centrifuge but not during the whirling in the electrical centrifuge.

5. Steam centrifuge was run at 15# pressure.

6. Tests were completed by the standard method.

7. The standard method of testing was used except as to the modifications as pertain to this experiment.

Results - The following chart summarizes the number of whirlings and the length of whirlings that may be safely used in securing acceptable tests. It is understood however, that proper tests cannot be obtained unless the cream has been burned to the proper color before centrifuging. This data is taken from experiments with cream testing from twenty (20) to forty (40) percent.

Steam centrifuge	Electrical centrifuge
5-2-1	5-2-1
5-3	5-3
5-2	4-3-1
4-3-1	4-3
4-3	
5-3-1	
4-2	

It will be noted in table 5 that 20 percent cream can be centrifuged 1-1 and still obtain acceptable tests. This sort of centrifuging cannot be applied to cream testing 30 to 40%.

Results from centrifuging 4-1 down to 1-1 show no variation in properly made tests of 20 percent cream, but the chances of securing proper appearances of the fat column are very much reduced. In fact between 1 to 2 tests are OK from 4 to 6 samples that are run. It cannot be advised therefore that correct fat percentages can be obtained unless the centrifugings as listed in the summarized chart are adhered to.

It is also noted that any percent of variation due to centrifugings considered as not OK, is slight from 1.1 - .3 percent. This is true where the fat columns were clear in color even though the color should not be considered ideal.

Conclusion - Best tests are obtained by centrifuging a third time, since the last whirling clarifies the column, which seems desirable from the standpoint of obtaining a correct reading.

It is recommended that centrifugings as listed in the summarized chart be adhered to.

Table XX. Effect of centrifuging at various temperatures.

Test of cream percent	Test bottles taken direct from centrifuge	% Difference	Test after immersion in water bath 135° -140°F	% Difference in water bath	% Increase due to water bath	% Decrease or increase due to various temperatures	Appearance of fat column	No. of trials	Temperature of centrifuge
23.0	22.5	.5	23.0	None	.5	Decrease .5	OK	4	Cooled by ice water
23.0	22.7	.3	23.0	None	.3	Decrease .3	OK	4	Room temperature
23.0	23.5	.5	23.0	None	Decrease .5	Increase .5	OK	4	Steam heated
29.5	29.0	.5	29.5	None	.5	Decrease .5	OK	4	Cooled by ice water
29.5	29.2	.3	29.5	None	.3	Decrease .3	OK	4	Room temperature
29.5	30.2	.7	29.5	None	Decrease .7	Increase .7	OK	4	Steam heated
29.5	29.9	.6	29.5	None	.6	Decrease .6	OK	4	Cooled by ice water
29.5	29.0	.5	29.5	None	.5	Decrease .5	OK	4	Room temperature
29.5	30.3	.8	29.5	None	Decrease .8	Increase .8	OK	4	Steam heated

Discussion of Table XX.

Object - To determine the effect of centrifuging at various temperatures upon the percent butterfat and appearance of the fat column.

Importance - This is of consideration because of the controversies which arise relative to type of centrifuge to purchase in order that the most suitable tests can be made. Hand and electrical centrifuges are unheated. Occasionally the latter are steam heated. Steam centrifuges are steam heated.

Method of procedure -

1. 9 c.c. warm water and 17.5 c.c. of acid was added to the cream, thoroughly mixed and centrifuged. Tests were completed using the standard method.

2. Percentages were read as bottles were taken direct from centrifuge, and after immersion in a water bath of 135°F to 140°F. This applies to test bottles centrifuged at various temperatures. Differences in percent are recorded.

3. Twenty, thirty and forty percent cream were used as a basis of comparison.

4. The standard method of testing was used except as to the modifications as pertain to this experiment.

Results - The following chart summarizes the change in percent due to centrifuging at various temperatures and after immersion in a proper temperatured water bath.

Test of Cream percent	Temperature during centrifuging		
	Cooled by ice water - decrease	Room temperature - decrease	Steam heated + increase
23.0	.5	.3	.5
29.5	.5	.3	.7
39.5	.6	.5	.8
Average	.53	.37	.67

Discussion of results - Results of centrifuging in a machine cooled by ice water reduces the percentage on the average .53 percent for cream testing twenty to forty percent.

Centrifuging in a machine at room temperature reduces the percentage on the average .37 percent, for cream testing twenty to forty percent.

Centrifuging in a steam heated machine increased the percentage on the average .67 percent, for cream testing twenty to forty percent.

It is also to be noted that after test bottles were immersed for three minutes in a proper temperature water bath of 135°F to 140°F, the percentage corresponds to the correct test.

Conclusions - Centrifuging in unheated machines reduces the readings from .37 to .53 percent for cream testing twenty to forty percent. In steam heated centrifuges the readings are increased .67 percent for twenty to forty percent cream. It is therefore advisable to standardize the temperature at which the tests should be read. This is best accomplished by a 135° -140°F water bath.

Table XXI. Effect of different temperatures on expansion of fat column of properly made tests.

Temperature of water bath	Test of cream	Test due to varying temperatures	Increase above normal temperature	Decrease below normal temperature	Remarks	Samples tried
	(20.0	20.55	.55		Temp. too high	3
190°F	(29.5	30.5	1.0		" " "	3
	(40.0	41.5	1.5		" " "	5
	(20.0	20.5	.5		" " "	6
180°F	(29.5	30.2	.7		" " "	3
	(40.0	40.8	.8		" " "	4
	(20.0	20.3	.3		" " "	6
160°F	(29.5	29.75	.25		" " "	2
	(40.0	40.4	.4		" " "	4
	(20.0	20.0	OK	OK	OK	4
140°F	(29.5	29.5	OK	OK	OK	3
	(40.0	40.0	OK	OK	OK	4
	(20.0	19.8		.2	Temp. too low	6
120°F	(29.5	29.2		.3	" " "	2
	(40.0	39.5		.5	" " "	4
	(20.0	19.6		.4	" " "	3
100°F	(29.5	29.0		.55	" " "	2
	(40.0	39.45		.55	" " "	3
	(20.0	19.5		.5	" " "	3
80°F	(29.5	28.5		1.0	" " "	3
	(40.0	39.0		1.0	" " "	3
	(20.0	19.0		1.0	" " "	3
60°F	(29.5	28.0		1.5	" " "	2
	(40.0	38.5		1.5	" " "	2

Discussion of Table XXI.

Object - To determine the effect of different temperatures on the expansion of the fat column of properly made tests.

Importance - The various station operators did not adopt a standard temperature at which the readings were made. Readings were usually made the same from unheated machines as from the heated. Since the fat separated solidifies at about 100°F, the temperature at which readings are made should have a limited range.

Method of procedure -

1. Only tests of proper color, free of foreign material were used in this experiment.

2. Test bottles were placed in a water bath of desired temperature for five minutes before readings were recorded.

3. A tight jointed pair of dividers was used for measuring the fat.

4. The percent increase above normal temperature and percent decrease below normal temperature was recorded.

5. 140°F was taken as the normal temperature.

Results - The following chart summarizes the effect of various temperatures upon the expansion of the fat column.

Test of cream	190°F	180°F	160°F	140°F
	Percent increase			
20.0%	.35	.50	.30	OK
29.5	1.00	.7	.25	OK
40.0	1.50	.8	.4	OK

Test of cream	120°F	100°F	80°F	60°F
	Percent decrease			
20.0%	.2	.40	.5	1.0
29.5	.3	.50	1.0	1.5
40.0	.5	.55	1.0	1.5

It is noted that for 20% cream, there is an expansion of the fat column from .3 to .35 percent from temperatures 160°F to 190°F. For 30% cream, an expansion from .25 to 1.0 percent from temperatures 160°F to 190°F. For 40% cream, an expansion from .4 to 1.5 percent from 160°F to 190°F.

Below the normal temperature of 140°F, the percentage is reduced for 20 percent cream from .2 to .4; for 30 percent cream .3 to .5; for 40 percent cream .5 to .55, for temperatures of 120°F to 100°F.

Between temperatures of 80°F and 60°F, the percentages reduced from .5 to 1.0 percent for 20% cream; 1.0 to 1.5 percent for 30% cream; 1.0 to 1.5 percent for 50% cream.

The following chart summarizes more generally the effect of temperatures upon the expansion of the fat column, giving the average percent increase and decrease.

Test of cream	140-120°F	120-100°F	80-60°F
	Average percent increase	Average percent decrease	
20.0%	.45%	.3%	.75
29.5%	.65	.4	1.25
40.0%	.90	.53	1.25

Temperature plays an important part in obtaining the correct butterfat percentage after tests have been properly made. Percent will vary with the expansion of the fat column.

Conclusion - Since it is necessary to have some standard for the proper expansion of the fat column to secure proper readings, the use of a water bath at temperature of 135°F - 140°F is recommended in reading all varying percentages of cream.

Table XXII. Effect of using varying temperatures of water during centrifuging on percent butterfat and appearance of fat column. (Temperature of acid and cream 65°F - 70°F).

Steam centrifuge

Degrees Fahrenheit	Richness of cream									No. of trials
	% 23.5	% Var.	Appearance of F.C.	% 29.5	% Var.	Appearance of F.C.	% 39.5	% Var.	Appearance of F. S.	
40°F	23.5	none	OK	29.5	none	OK	39.5	none	OK	4
50°F	"	"	"	"	"	"	"	"	"	4
60°F	"	"	"	"	"	"	"	"	"	4
70°F	"	"	"	"	"	"	"	"	"	4
80°F	"	"	"	"	"	"	"	"	"	4
90°F	"	"	"	"	"	"	"	"	"	4
100°F	"	"	"	"	"	"	"	"	"	4
110°F	"	"	"	"	"	"	"	"	"	4
120°F	"	"	"	"	"	"	"	"	"	4
130°F	"	"	"	"	"	"	"	"	"	4
140°F	"	"	"	"	"	"	"	"	"	4
150°F	"	"	"	"	"	"	"	"	"	4
160°F	"	"	"	"	"	"	"	"	"	4

Discussion of Table XXII.

Object - To determine the effect of using varying temperatures of water during centrifuging on percent butterfat and on the appearance of the fat column. The temperature of acid and cream maintained at 65°F, 70°F. A 24 bottle Babcock steam centrifuge was used.

Importance - Many operators were in dispute over the temperature of water to add after the first and second whirlings. Most of them, however, used hot water.

Method of procedure -

1. To carefully weighed 9 gram cream samples, 9 c.c. acid was added and the mixture burned to a proper color, after which a few c.c. of warm water was added to prevent burning of the fat.

2. Test bottles were then centrifuged in a steam machine 5-2-1 minutes and varying temperatures of tap water were added after the first and second whirlings, as indicated in the table.

3. Readings were made after test bottles were immersed in 135°F - 140°F water bath for three minutes.

4. The appearance of the fat column and the percent was noted and recorded.

Results - It was found that low temperatures of water added to the test bottles after the first and second whirlings produced no abnormal appearing fat columns and did not alter the percentage. These results were obtained by using a 24 bottle steam Babcock centrifuge having steam turned in during the whirlings. The results of applying the experiment to an unheated hand or electric centrifuge were not determined.

Conclusions- It is recommended that even though satisfactory results were obtained by using water of low temperature in a steam machine, that warm to hot water be used. It is not necessary, to fear unsuitable results, however, if cold water is used, provided a steam heated and driven centrifuge is used.

Table XXIII. Effect of using red reader on fat column on percent butterfat.

No. of trials	Percent cream with methods	Percent cream using red reader	Percent difference due to glycol	Temperature of reading
1	20.5	20.0	.5	135°F-140°F
2	20.55	20.0	.55	"
3	20.5	20.0	.50	"
4	20.6	20.0	.60	"
5	30.9	30.0	.9	"
6	30.9	30.0	.9	"
7	30.8	30.0	.8	"
8	40.5	39.5	1.0	"
9	40.5	39.5	1.0	"
10	40.5	39.5	1.0	"

Discussion of Table XXIII.

Object - To determine the change in percentage of butterfat due to the use of red reader.

Importance - Station operators frequently deducted from one to two percent for the meniscus when not using glymol. Upon the assumption that such allowances resulted in incorrect readings even of properly made tests, induced investigations of this kind.

Method of procedure -

1. After tests were properly made, the test bottles were lowered into a proper temperatured water bath and left immersed for three minutes, before readings were made.

2. Readings were first made including the meniscus. The second readings were made after glymol had been added to the fat column. The difference in percent was then recorded.

Results - The following table briefly summarizes the effect of using glymol when readings were made at proper temperatures.

	Test of Cream		
	20%	30%	39.5%
Average percent decrease due to glymol	.54	.86	1.0

The above figures show the necessity of using glymol. The table shows the average percent reduction of .5% for 20% cream; .8% for 30% cream and 1.0% for 40% cream.

Glymol has a tendency to produce a feathery mixture at the surface of the fat column if allowed to remain there for any length of time, so it was applied immediately before making the readings, to eliminate the possibility of error.

Conclusion - Merely making rough allowances for the nervous results in an unnecessary percentage of error. The use of a few drops of glymol is consequently recommended.

SUMMARY

The higher efficiency of the standard method is unquestionable.

9 c.c. water (60-70°F) added to a 9 gram cream sample previous to the addition of 17.5 c.c. acid, permitted a range of acid temperatures from 70°F to 130°F.

Where 9 c.c. of acid was added the temperature of the acid was more limited, from 45°F to 80°F being acceptable. Since the acid temperature at cream stations is apt to be between 75°F and 90°F, rather than from 45°F to 60°F, it is recommended that the addition of 9 c.c. water (60°F - 70°F) and 17.5 c.c. acid be used for testing cream of unknown fat content.

The water permits higher range of acid and cream temperatures and satisfactory results are more certain of being obtained.

9 c.c. water (same varying temperatures as cream) added to a 9 gram cream sample previous to addition of 17.5 c.c. acid, allowed a range of temperature for the cream from 40°F to 90°F.

Where 9 c.c. of acid was added to the 9 gram cream sample, the temperature of the cream was limited from 40°F to 70°F. It is recommended from a testing standpoint that cream patrons maintain as low a temperature of their cream as possible prior to delivery.

8 - 10 c.c. acid added to a 9 gram cream sample permits a temperature of 45°F to 70°F, for both the acid and cream. Temperature of both acid and cream has much to do in securing properly made tests. It is therefore recommended that the temperatures of the cream and acid be low, 45°F to 70°F, rather than high, since a constant amount of 8 - 10 c.c. acid may be used within such a temperature radius.

With a constant temperature of acid and cream (65°F - 70°F) the following amounts of water at different temperatures previous to the addition of 17.5 c.c. acid are required. This is prior to centrifuging, 9 c.c. water, 85°F - 100°F, 12 - 14 c.c. water, 110°F - 130°F; 14 - 16 c.c. water, 140°F - 160°F. Using 9 c.c. of water at temperatures of 90°F and 100°F

gave the best appearing fat columns. However, satisfactory results are obtained by using 9 c.c. water at temperatures of from 95°F to 100°F.

Best tests are obtained by centrifuging a third time, since the last whirling clarifies the column. This is desirable from the standpoint of correct readings.

Centrifuging in unheated machines reduces the readings from .37 to .55 percent. In steam heated centrifuges the readings are increased .37 percent. This applies to cream testing twenty to forty per-cent. It is therefore advisable to standardize the temperature at which the tests should be read. This is best accomplished by a proper temperatured water bath 135°F - 140°F.

Hot water should be added to the test bottles after the first and second whirlings. This applies more especially to unheated centrifuges. In steam heated and steam driven centrifuges cold water (50°F) may be added.

The use of glymol (red reader) reduces the readings for twenty percent cream .5 percent; for

for thirty percent cream .8 percent; and for forty percent cream 1.0 percent. Its use is consequently recommended in place of merely making weight allowance of one to two percent for the meniscus.

Temperature plays an important part in obtaining the correct butterfat percentage after tests have been properly made. Since it is necessary to have some standard for the proper expansion of the fat column, to secure proper readings the use of a water bath at a temperature of 135°F - 140°F is recommended in reading all varying percentages of cream.

CONCLUSION

For a period of many years the mass of facts which has accumulated on the subject of cream testing has served to demonstrate the complexity of the problem from both its economic and scientific aspects. One of the principal conclusions from the evidence presented in this thesis is that commercial methods should be standardized with a rigid State law enforcement.

LITERATURE CITED

Only a few of a large number of references are hereby submitted, from which data verbatim have been taken. A complete list of all references used would be extraneous.

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