SOME FACTORS OTHER THAN BACTERIA THAT INFLUENCE THE BODY AND FLAVOR OF GRANULED BUTTERMILK

THESIS FOR THE DEGREE OF M. S.

Donald Brock Goodwillie

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Buttermilk

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Thesis

Respectfully submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of Master of Science.

by

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INTRODUCTION

Within the past few years a new type of buttermilk has made its appearance on the market. This product, termed granuled buttermilk, is simply a cultured buttermilk which contains small flakes, or granules, of butter. Granuled buttermilk has been developed in response to a demand for an old-fashioned churn buttermilk which always contained some butter granules. While the newly developed product does not resemble old-fashioned buttermilk in every detail, there is a striking similarity.

Few dairy beverages have gained greater popularity than buttermilk. It is a universal favorite and extensively used on account of its flavor and beneficial effects. While it is popular as a beverage, it is used extensively in many recipes, making delicious dishes.

The development of granuled buttermilk is the natural outgrowth resulting from the widespread knowledge and extensive use of buttermilk. Within recent years buttermilk has become very popular in the United States, due largely to its medicinal properties in the treatment of certain diseases and to its valuable food properties. Medical science recognizes the value of good buttermilk as a food. It is often prescribed by doctors for babies with weak digestion and for older people as a beverage in certain disorders, while healthy people are advised to drink more of it. Buttermilk is easily digested and possesses a certain medicinal value. Its food value is about equal to sour skim milk. Like skim milk it contains water-soluble vitamins, protein, and mineral matter, and furnishes these valuable essentials at a very low cost. Because it is simply and easily made, it can be had where dairying is practiced at all seasons of the year.

There are two general classes of buttermilk, namely, natural, or churn buttermilk, and commercial, or artifical, buttermilk. The former is the product remaining after the butter has been removed from a churning of cream, while the latter is an artificially prepared product resulting from the souring of skimmilk with a lactic culture after which the coagulum is churned to a smooth consistency.

Many of the dairy companies making granuled buttermilk have experienced difficulty in making a uniform product which meets with the public demand. Some obscurity prevails in making a desirable product. Several companies have paid large sums of money for the formulae for making such a product. Very little, if any, research work has been done dealing directly with this type of buttermilk. In view of these facts a study of the methods of manufacture of granuled buttermilk with its associated problems seemed desirable.

In this study an attempt has been made to arrive at a method of making old-fashioned buttermilk containing granules of butter so that all the features of the old-fashioned product would be embodied without the undesirable qualities, such as wheying off, unnatural flavors, and poor body, which are so common in the churn product.

REVIEW OF LITERATURE

Records of experimental work directly related to granuled buttermilk could not be found in the literature, probably due to the fact that this product is a recent addition to the list of dairy products. However, considerable experimental data were available on the properties of other fermented milks, which seemed to be of very great importance to the successful manufacture of granuled buttermilk. Since many fermented milks have several properties in common, a survey of the literature dealing with these properties was thought to be of value.

Methods of Manufacturing Buttermilk

Several investigators recommend different methods for making commercial starters and buttermilk.

The qualities of a good grade cultured buttermilk have been defined by Burke (8) as one "having a mild, rather sweet, acid flavor, should be viscous and creamy in appearance, and after curdling should break up readily into a fine, flocculent, smooth, homogeneous mixture, containing no lumps and show no wheying off when held for two days at low temperatures in storage."

In working with butter cultures Hammer (15) recommended using whole milk, pasteurized from 180° to 200° F. for 30 minutes, then cooled slowly to 70° or 72° F. after which enough inoculum was added to curdle the milk within 14 to 18 hours. Hunziker (17), working with bulk starters, recommended skimmilk, pasteurized at the same temperatures, then cooled to 68° F. in the summer and 72° F. in the winter, after which he added from two to four quarts of mother starter for each one hundred gallons of milk. He also recommended

incubation temperatures from 68° to 72° F. for 15 to 16 hours.

Lang (19), in his method of improving buttermilk from pasteurized cream, used a ten per cent culture of B. bulgaricus and, therefore, obtained a product of higher acidity in a shorter time. The culture was added at the rate of one to one and one-half pints per ten gallons of milk. Pasteurized whole milk was used. He further recommended incubation temperatures of 95° to 100° F. for 18 to 24 hours, or until the acid was developed from one and two-tenths to one and five-tenths per cent. This bulk culture was then added to natural buttermilk at the rate of ten to fifteen gallons to one hundred gallons of natural buttermilk, and then mixed by churning. This mixture gave an acidity in the final product of .65 to .85 per cent.

Using cultures of B. bulgaricus and Strep. lactis, Monrad and Spence (20) also found that skimmilk pasteurized at 170° F. for one hour, cooled immediately to 68° or 72° F., depending on the season, after which sufficient starter was added to insure curdling of the milk in fourteen hours, resulted in a good quality of cultured buttermilk. They stated that, owing to the differences in optimum growth temperature, the B. bulgaricus and Strep. lactis must be propagated separately. Rogers (23) recommended the same method as Monrad and Spence (20) in making cultured buttermilk, except that he recommended pasteruization of the skimmilk at 180° to 185° F. for 30 to 60 minutes. He also used a ten per cent B. bulgaricus starter.

The Canadian Department of Agriculture (11) report that buttermilk of good quality can be made from pasteurized or raw skimmilk. In either case a ten per cent lactic culture should be added to the milk at a temperature of 70° F. and allowed to stand at that temperature until coagulation took place.

The buttermilk was then placed into a churn and churned 30 to 40 minutes until a smooth product was obtained. This churned product was then strained through cheese cloth and stored at 40° F. until ready to use.

Burke (8) and certain dairy laboratories handling commercial starters (13) varied somewhat in their recommendations for manufacturing cultured buttermilk. Burke (8) found that heating the milk from 180° to 190° F., cooling immediately from 68° to 72° F., depending upon the season of the year, innoculating this milk with the smallest amount of culture which would bring about curdling within 15 to 18 hours, usually about two or three per cent, resulted in a very satisfactory product. The dairy laboratories (13) differed in that they advised pasteurizing at 190° F. for 20 or 30 minutes, then cooling to 70° F. They recommended two quarts of starter to 40 gallons of milk, ripening until .75 to .85 per cent acid was developed and then cooling to 50° F. before breaking up the curd.

A satisfactory churn buttermilk, according to Ruehe (21) was made by taking 12 per cent milk cooled to 45° or 48° F. and churned until small butter granules were formed. Sufficient bulk lactic culture was then added until the fat content was diluted down to about one or two per cent fat. The product was then agitated by churning, cooled to below 50° F., and bottled.

Wheying Off

Wheying off of buttermilk is effected by several factors. Bates and Tolman (3), Burke (7), and Yaxis (26) all agreed that the addition of .25 per cent of high grade gelatine retarded wheying off for longer periods than where gelatine was not used. Burke found that the best results were obtained when the gelatine was added after heating the milk to 190° F. Yaxis noted that the

addition of gelatine would retard wheying off for as long as five days if the cultured buttermilk was kept at temperatures of 40° to 45° F. Button (6) observed that the use of gelatine to prevent wheying off was not necessary in the preparation of a good quality cultured buttermilk, if pasteuring temperatures above 155° F. were used.

In describing some of the properties affecting cultured buttermilk, Burke (8) found that metals which were responsible for metallic flavors, namely, copper and zinc, had no effect on wheying off of cultured buttermilk. He stated that wheying off was caused by vigorous agitation, agitation for long periods of time, warming the cultured buttermilk from 75° to 90° F. before breaking the curd, and storing for long periods, especially at temperatures around 75° F. To overcome this defect he advised breaking the curd without undue agitation, beginning the process at 65° F., cooling rapidly to a temperature of 45° F., or lower, and then storing at temperatures of 35° to 40° F. Monrad and Spence (20) also confirmed Burke's (8) findings in that, if the agitation in breaking the curd was moderate, a smooth, velvety product was obtained, but if the agitation was violent, a foamy product and a separation of the curd invariably resulted.

If the skim milk were allowed to remain long after coagulation before being broken up, according to the Canadian Department of Agriculture (11), the finished product would show a greater tendency to whey off.

One of the dairy laboratories (13) stated that if whey appeared on top of the cultured buttermilk, the buttermilk had not been ripened enough, or else the buttermilk had become contaminated through bad milk, or utensils. On the other hand, if the whey were at the bottom of the container, impure starters, foreign bacteria, or over ripening was usually the cause. Guthrie and Fisk

(14) also concluded that over ripening caused wheying off, claiming that over ripening produced a hard and somewhat tough curd which contributed to an intensity of this defect. Monrad and Spence (20) stated that wheying off was the result of over ripening while propagating at too high a temperature together with improper cooling and storage.

Knaysi (18) advanced the theory that a tendency to whey off at high temperatures of incubation was a physical phenomenon, comparing the coagulum to a sponge full of small capillaries. He claimed that an increase of temperature decreased the amount of serum these capillaries would hold, and, that rapid coagulation decreased the absorptive power of the coagulum, thus wheying off occurred.

According to Ross (22) wheying off increased as the product aged and as the per cent of acid increased, and could be partly remedied by churning the cultured buttermilk the same as genuine buttermilk was churned. This process separated the particles of casein so finely that they stayed in suspension much better than they would otherwise. He also maintained that if the product were allowed to warm up to such a temperature that the acidity increased very rapidly, wheying off would occur.

Both Button (6) and Knaysi (18) found that homogenization, or viscolization, of cultured buttermilk regardless of temperatures or pressure used, gave a marked separation of the serum from the coagulum.

Factors Affecting Physical Qualities of Buttermilk

It is a recognized fact that in general there are three main essentials which determine the quality of buttermilk. These are, flavor, body, or texture, and viscosity.

In determining the effect of different factors on the body of cultured buttermilk, Knaysi (18) found that a large quantity of inoculum would increase the lump content of the buttermilk and would produce a firmer curd. At low incubation temperatures the quantity of inoculum was a minor factor, but increased in importance as the incubation temperature was raised. He further stated that when skim milk was pasteurized at 65° C. for 30 minutes and inoculated, that the resulting inoculum was of very poor quality, being of a sandy and of a weak texture. Pasteurizing at temperatures from 82° C. to 100° C. for 15 minutes gave a much better bodied buttermilk than when pasteurized at 62° C. for 30 minutes. Incubation temperatures of 37° C. also gave the greatest amount of undesirable lumps, and increased the viscosity to a greater degree than when incubated at room temperatures.

Bell and Burkey (5) found that an increase in viscosity of buttermilk was due to a high and prolonged heat treatment of the skimmilk. They attributed this to an increase in the total solids content of the skimmilk as the result of the evaporation of water. Bateman and Sharp (2) and Dahlberg and Henning (10) maintained that skimmilk increased in viscosity with age, and decreased with pasteurizing, while agitation had no effect. Ruehe (21) found that vigorous agitation decreased the viscosity of the buttermilk.

To increase the body of cultured buttermilk Monrad and Spence (20) advocated the addition of one per cent dry skimmilk powder. Bell (4), however, stated that dry skimmilk would increase the viscosity of cultured buttermilk, but that it might have a bad effect on the body of the buttermilk. He further stated that milk sugar in amounts of five-tenths to one per cent had no effect on the body or viscosity of the product. Burke (7), Reid and Welch (24), and Yaxis (26) all agreed that gelatine increased the viscosity and improved the

body of cultured buttermilk. Knaysi (18) found that gelatine had no effect on the lump content of cultured buttermilk and that the use of starch in concentrations of one-tenth to five-tenths of one per cent increased lumpiness and viscosity. Burke (7) further stated that the addition of gelatine gave a softer curd which was broken up more easily.

The use of skimmed, Jersey milk in the manufacture of cultured buttermilk, according to Bell (4), gave a more viscous and more staple product than that made from skimmed, Holstein milk. He explained this by saying that the greater viscosity of Jersey milk was due to an increase in the colloidal solids.

Burke (8) found that the viscosity increased with the higher temperatures of heating, but was chiefly dependent on the vigor of the culture used, the temperature of incubation, and the amount of acidity developed. He also stated that a lack of viscosity was directly associated with wheying off, poor flavor, and appearance. Hunziker (17) noted that unless the starter had developed a reasonable amount of acid, .75 to .80 per cent, the body of the cultured buttermilk was poor.

Factors Affecting Flavors of Buttermilk

Flavor is one of the important qualities to be considered in making cultured buttermilk. Consequently considerable attention has been given to it by several investigators.

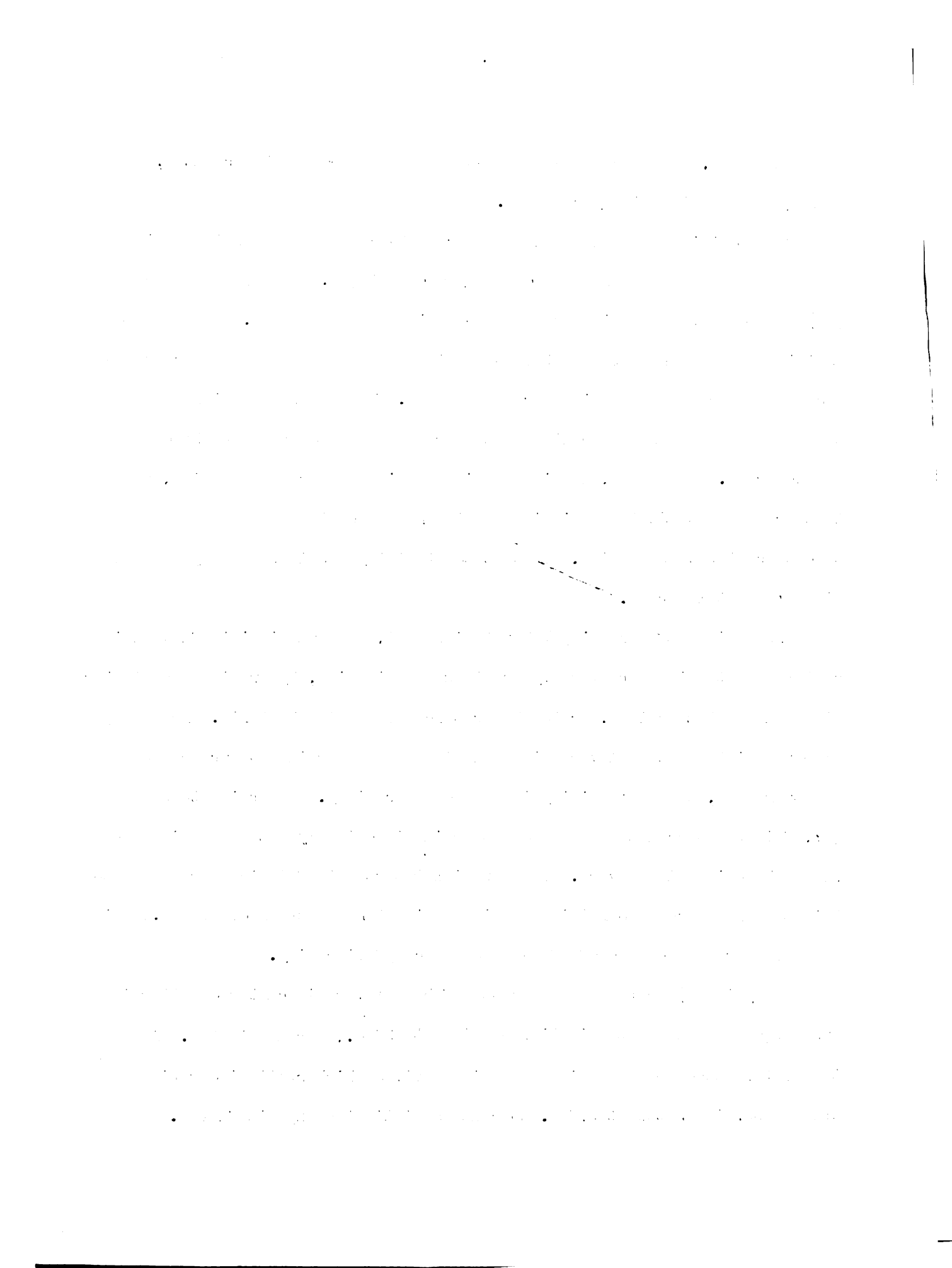
Bates and Tolman (3), Burke (7), and Yaxis (26) agreed fairly well that gelatine had very little, if any, effect on the flavor of cultured buttermilk, but where a noticeable difference did occur, the flavor tended to be slightly inferior. Bell (4) claimed that milk sugar added at the rate of five-tenths to one per cent by weight improved the flavor of the cultured product. In his experiments with flavor Knaysi (18) added starch to cultured buttermilk

and found that, when amounts over two-tenths of one per cent were used, starchy flavors invariably resulted.

The addition of small amounts of cream to cultured buttermilk to improve the flavor has been recommended by Campbell (9). Monrad and Spence (20) stated that whole milk or cream would improve the flavor, and that the addition of ten per cent of water would give the product nearly the consistency of buttermilk as obtained from the churn. The amounts of milk and cream to add depended upon the quality of the product desired and upon the demand of the trade. Burke (8), in his experiments with cultured buttermilk, found that from all standpoints skimmilk was the most acceptable for the manufacture of cultured buttermilk, but that palatability was increased by the addition of a little cream.

According to some dairy laboratories (15), flat and insipid flavors in cultured buttermilk were largely due to under ripening, by growing the starter at too low a temperature, or to the presence of foreign bacteria. Ross (22) also associated these flavors with allowing the buttermilk to warm up to such a temperature, that the acidity increased too rapidly. According to Campbell (9), failure to cool the cultured buttermilk immediately after churning caused other objectionable flavors. The Canadian Department of Agriculture (11) attributed off flavors to raising the incubation temperature above 70° F., while Burke (8) associated the off flavor to a lack of viscosity.

Knaysi (18) found that the cause of bad flavors in cultured buttermilk was largely due to pasteurization of milk at 82° C., for 15 minutes. At this temperature some spore forming bacteria survived which multiplied rapidly enough when incubated at 57° C. to cause a distinct change in flavor.



Salt was recommended by Monrad and Spence (20) to improve the flavor of buttermilk. Burke (8) stated that the addition of one-tenth of one per cent salt altered the flavor and was not considered to be beneficial.

In connection with his work with metals, Burke (8) found that the high acidity of cultured buttermilk tended to produce a metallic flavor in the product when such metals as copper and zinc were used in its manufacture, while tin and aluminum had little or no effect.

Hunziker (17), working with butter starters, claimed that unless .75 to .80 per cent acid was present there was a decided lack of flavor and aroma. When acidities were above .85 per cent the flavor was too sharp whereas when the acidities were below .70 per cent the flavor and aroma were usually under developed. Burke (8) agreed with Hunziker (17) in that the acidity should be from .75 to .85 per cent, if the best flavor and aroma were to be obtained.

Both Rogers (23) and Reid and Welch (24) obtained the best flavor and aroma in cultured buttermilk by using a ten per cent culture of B. bulgaricus mixed with a Strep. lactis culture and cooling the curd prior to breaking.

Hammer and Hauser (16) found that the chief defects in flavor of cultured buttermilk were caused by excessive saltiness and acetic acid.

Factors Affecting Acidity of Buttermilk

Bates and Tolman (3) and Burke (7) maintained that gelatine had no effect on the development of acidity of cultured buttermilk. Yaxis (26) disagreed with them and claimed that the addition of gelatine retarded the development of acid in the product.

The Canadian Department of Agriculture (11) and Hunziker (17) found that lowering the temperature after breaking the curd to below 50° F. checked the production of acid. Ross (22) stated that if the cultured buttermilk was

allowed to warm up to room temperature, the acidity increased very rapidly, and that the older the product became the greater the amount of acid produced up to a certain point.

Knaysi (18) observed that an increase in the amount of inoculum gave an increase in the amount of titrateable acidity. He further observed that the acidity was produced more rapidly at 37° C. than at room temperature up to a certain point, but after coagulation took place, acid production at 37° C. was retarded, while at room temperature the development of acidity continued until the amount of acid produced was greater than at 37° C. Knaysi (18) also found in his work with sodium salts, that these salts increased the amount of titrateable acidity. He showed that the amount of acid formed in cultured buttermilk varied directly with the amount of salt added and with the concentration of the lactic acid.

Factors of Heat Treatments of Milk Intended for Manufacture into Cultured Buttermilk

There was a great difference of opinion as to the correct temperature that should be used in heating skimmilk for the manufacture of cultured buttermilk. In a review of the literature, temperatures ranging from 145° F. for one hour to 200° F. for 30 minutes were suggested.

In the making of large amounts of culture, Hunziker (17) recommended pasteurizing the milk at 180° F. and holding it at that temperature for at least one hour. He claimed that it was not desirable to heat for a longer period or at a higher temperature, as exposure to excessive heat tended to caramelize the milk sugar. This changed sugar interfered with the normal bacterial action and, thus the quality of the starter might be sacrificed.

In agreement with Hunziker (17) Reid and Welch (24) in their work with reconstructed milk found that temperatures above 180° F. impaired the flavor and aroma by causing a milk powder taste and odor to become apparent. They also recommended pasteurizing the milk at 180° F. for 30 to 60 minutes.

In a series of experiments to determine the effect of heating milk on the body of buttermilk, Knaysi (18), using three different lots of milk, heated and held one lot to 100° C. for 15 minutes, another to 82° C. for 15 minutes, and the third to 65° C. for 30 minutes. He found that milk pasteurized at temperatures of 65° C. for 30 minutes failed to coagulate within twenty-four hours and often two or three days were required. When coagulation did occur and the coagulum was finally broken up, a sandy, weak-bodied buttermilk resulted. He claimed that the slow coagulation together with a foreign flavor was due to resistant bacteria which survived pasteurization, and which prevented the development of the lactic bacteria. A certain colloidal factor may also have been responsible for this failure to coagulate. However, he found that when the milk was heated to and held at 82° C. and 100° C., there was a marked improvement in the body. He concluded that 100° C. for 15 minutes was the best temperature of heating the milk to obtain the best bodied buttermilk.

Burke (8), in his experiments with heat treatment of milk on quality of cultured buttermilk, found that 145° F. applied for longer than 30 minutes gave a flat, cooked flavor, while the curd of the milk was coarse and unevenly distributed. Using temperatures of 145° F. for 30 minutes, much the same results were obtained, except that the curd particles were smoother and more evenly distributed. He also found that using temperatures of 160°,

170°, 180°, and 190° F. applied for 30 minutes were unnecessary for good quality. He based this statement on the fact that unless the skimmilk was flash pasteurized that considerable time was required to heat the milk to 190° F. and by the time this temperature had been reached the milk was practically bacteria free and, therefore, it was unnecessary to hold the milk at that temperature to obtain good results.

Per cent Acidity and Fat of Cultured Buttermilk

There seems to be some difference of opinion as to the correct acidity and amount of fat cultured buttermilk should contain. Guthrie and Fisk (14) claimed that the acidity should be about seven-tenths of one per cent and that the fat content should be between five-tenths and one and five-tenths per cent. In connection with their studies of market milk in Iowa, Hammer and Hauser (16) found the average acidity of cultured buttermilk was .857 per cent and that all the samples tested contained less than one per cent fat.

Burke (8), Hunziker (17), Lang (19), and certain Dairy Laboratories (13) varied somewhat in their recommendations as to the correct amount of acid that should be present. Burke (8) suggested .80 to .85 per cent while a dairy laboratory (13) and Hunziker (8) recommended .75 to .85 per cent. Lang (19) used a mixture of B. bulgaricus and Strep. lactis cultures and advised an acidity of .65 to .85 per cent.

PURPOSE OF THE EXPERIMENT

This experiment was undertaken for the purpose of investigating some of the difficulties incident to the manufacture of granuled buttermilk, of studying some of the factors which influence the flavor and body of this product, and of determining the most suitable correlation of factors which would yield the maximum quality of finished product. With these aims in view, the following phases of the work were studied in detail:

1. Comparison of some physical and chemical properties of churn and cultured buttermilk.
2. Determination of the best method of manufacturing granuled buttermilk that would embody as many of the good properties of old-fashioned churn buttermilk as possible.
3. Determination of the minimum and optimum viscosity at which the granules remain evenly dispersed.
4. Study of the effect of the butter granules on the wheying off of granuled buttermilk.
5. Determination of the optimum amount of butter granules to add in order to obtain the best flavor and the most pleasing appearance.
6. Study of the effect upon granule dispersion of different temperatures of mixing and storing granuled buttermilk.
7. Study of the effect of adding different quantities of cream on the flavor of the product.
8. Study of the effect of size of granules on dispersion.

PLAN OF EXPERIMENTAL WORK

Source of Cultured Buttermilk

In order that the results of this work should apply to commercial conditions in so far as possible, it was thought desirable that the bulk culture used in these experiments should be of good quality, and yet one which was being manufactured on a commercial scale. Accordingly, the cultured buttermilk made in the college creamery was selected to be used in this experiment. Excepting where notations were made to the contrary, this buttermilk met the high standards demanded by the public for this product. In general, this cultured buttermilk was made as described below.

The mother starter was carried from day to day in clean, quart bottles. These were filled two-thirds full of whole milk, pasteurized at 200° F. for one hour and then cooled to 70° F. At about 4:30 in the afternoon the cultures from the previous days' inoculation were examined carefully. The one adjudged best was used to inoculate the bottles of whole milk. Enough of the inoculum was used, so that the inoculated milk would be well coagulated within 14 to 18 hours, or by the next morning. The cultures were incubated in a Mojonnier culture oven at a temperature of 70° F. As soon as the inoculated milk in the bottles was firmly coagulated, it was placed in a refrigerator, the temperature of which was 40° F. where it was held until used for propagating a new culture, or for inoculating the skimmilk for making the cultured buttermilk.

The cultured buttermilk was made in a Pfaudler, glass-lined fifty-gallon pasteurizer. Forty gallons of skimmilk were pasteurized in this vat

at 190° F. and held at this temperature for one hour. This skimmilk was then cooled to 70° F., when one-half pint of the mother culture was added and thoroughly mixed by agitation. Under the conditions given, this amount of starter was found to be sufficient to curdle the milk within 14 to 18 hours, or over night. The following morning, the coagulum was broken up by gentle agitation, which required about three minutes. The cultured buttermilk was then drained into ten gallon milk cans and placed in the refrigerator at 40° F. until used.

The churn buttermilk of which the physical and chemical properties were studied, was obtained from regular churnings of cream as performed in the college creamery.

The cream used in making the butter was obtained from that delivered by the farmers of the district.

When the cream was received, it was weighed and then dumped into a two hundred gallon Wizard vat. Tests were made to determine the acidity and fat content, the average amounts present being five-tenths of one per cent acidity and 34 per cent fat. The cream was warmed to 90° F. and neutralized to approximately .25 per cent acidity by adding a solution of calcium hydrate and thoroughly mixing it with the cream at 90° to 100° F. for five minutes, before further heating. The cream was then heated to 145° F. and held at that temperature for 30 minutes, after which it was cooled to 100° F. Three per cent of starter was added and the cream further cooled to 48° F. The cooling was controlled, so that an hour to an hour and one-half was required to reach the desired temperature.

Churning was brought about in a Cherry Dreadnought churn of 750 pounds capacity. The churning temperature was so regulated that it would require

from 40 to 50 minutes for the cream to break. The temperatures ranged from 50° to 55° F. When the granules reached the size of grains of wheat, the churning was stopped and the buttermilk drained off. Pint samples of the buttermilk were taken after the first six or seven gallons had been removed. The buttermilk thus obtained, contained no perceptible butter granules and was representative of the average churn buttermilk.

Comparing Cultured and Churn Buttermilk

In comparing the properties of these two buttermilks the same methods for each were used. It was, therefore, thought unnecessary to describe the methods for each separately.

The flavor was determined by taste and smell in an endeavor to detect if possible any unnatural or foreign flavor that might be present.

In the acidity determination, nine cc. of a well mixed sample of buttermilk were placed in a clean beaker, a few drops of phenolpthalein indicator added and the whole titrated using a standardized solution of tenth normal sodium hydroxide. The results were reported as per cent lactic acid.

As there seemed to be a great many conflicting views on the correctness of fat tests on buttermilk as determined by using Babcock test bottles, various reagents, and so forth, it was thought more desirable to use the Mojonnier method. Both the total solids and fat determinations were made by this method.

The wheying off defect was studied in glass cylinders. A clean, dry 100 cc. graduated, glass cylinder was filled to the 100 cc. graduation mark with the sample of buttermilk. The cylinder was then placed in the refrigerator at a temperature of 40° F. for 72 hours. After 24, 48 and 72 hours the sample was removed and examined for visible whey, which might have appeared on top of the coagulum. The amount of whey appearing for each of the three

days was read in cubic centimeters and reported as per cent; each cubic centimeter of whey representing one per cent of whey.

The Westphal balance was used in making all the specific gravity determinations. No correction for temperature was made as the samples were adjusted to the correct temperature of 15° C. before being analyzed.

A MacMichael viscosimeter was used to determine the viscosities of the buttermilks. The method for each type of buttermilk was identical except that two different sized, or numbered, tension wires were used, a number 26 being used for the cultured buttermilk and a number 34 for the churn-buttermilk. The chief reason for the use of two wires was due to the differences encountered in the viscosities of the two buttermilks and the fact that the number 26 wire had too great a tension to be sufficiently accurate on such a non-viscous liquid as churn buttermilk.

In making the determination the machine was so balanced or leveled that the plunger hung in the center of the cup and the spindle in the center of the dash pot. The turntable was adjusted to 20 revolutions per minute. One hundred cc. of the buttermilk at a temperature of 20° C. were placed in the dash pot. After adjusting the pointer to the zero mark on the scale, the turntable was set in motion. The machine was allowed to run until the reading on the scale remained constant. The reading as obtained from the viscosimeter was in degrees which were changed to centipoises by means of standardized wires and the formulae C P/M = 34.69 x gm - CM/M. (25). The results were reported in centipoises.

Determining Size of Curd Particles

Two methods were used in determining the size of the curd particles of the cultured buttermilk. First, the Knaysi method (18), which consisted

in placing 300 cc. of water in a 500 cc. Erlenmeyer flask and then adding 100 cc. of cultured buttermilk using an additional 50 cc. of water for rinse purposes. The flask was then gently rotated ten times and allowed to stand for one minute. The contents were then poured over a Buchner funnel. Fifty cc. more water were used to rinse the flask. The curd remaining on the funnel was washed onto a small piece of weighed cheese cloth and air dried, after which it was re-weighed, and the results reported in per cent. This method is accurate to within ten per cent.

The second method which was used in determining the size of curd particles in the cultured buttermilk consisted in the same procedure as the above, except instead of pouring the contents of the flask over the Buchner funnel, they were poured through a weighed piece of cheese cloth, air dried, re-weighed, and the results reported in per cent. This method also gives only approximate results.

Owing to the non-viscous nature and lack of visible lumps the Knaysi method of determining the size of the curd particles in the churn buttermilk was unsatisfactory. A method somewhat similar to the Knaysi method was used. This consisted in pouring 100 cc. of the churn buttermilk through a piece of weighed cheese cloth, air drying, re-weighing and determining the per cent of curd particles retained on the cheese cloth. The results were reported in per cent. The results obtained with this buttermilk are also only approximate.

The microscope was also used to determine the approximate size of the particles in churn buttermilk. In the preparation of the sample for microscopic study special technique as used by Babcock (1) was employed. This consisted in diluting the buttermilk to be examined with a gelatine solution at

the rate of one part gelatine solution to ninety-nine parts buttermilk. The gelatine solution consisted of one and five tenths parts gelatine to ninety-eight and five tenths parts water with a few drops of phenol added as a preservative. This gelatine solution was used to hold the curd particles, and to eliminate the Brownian movement. A drop of the buttermilk and gelatine mixture was placed on a concave slide and examined under the high power, dry lens. An average of 12 fields were examined for each sample. The results of the field examinations were recorded as per cent of clusters and per cent of individual particles. The maximum and minimum as well as the average size of the particles were also determined by using a standardized eye-piece micrometer. The results were reported in microns.

Methods Used in the Manufacture of Granuled Buttermilk

There are two methods commonly used in the manufacture of granuled buttermilk. The first, termed the churning method, consists of adding the cream directly to the cultured buttermilk, after which the mixture is churned until the granules appear. The second method, called the granule addition method, differs in that sweet cream is churned until the butter granules reach the size of plump grass seed, after which the granules are well hardened by placing them in the refrigerator at 40° F., and then added in definite amounts to a good grade of cultured buttermilk.

Both of these methods were tried in this experiment. In working with the churning method, 3000 cc. of cultured buttermilk were placed in a six quart Dazey churn and 75 to 200 cc. of 40 per cent cream added. Churning was continued until the butter granules formed, after which cultured buttermilk was added in sufficient quantities to dilute the number of granules

present considerably. The product was then placed in the refrigerator at 40° F. until ready to be examined.

In the granule addition method of preparing granuled buttermilk a different procedure was followed. The granules were obtained by churning separately as described later. The granules, thus obtained, were mixed by gentle agitation into the cultured buttermilk in the desired amounts. As small amounts as possible of the churn buttermilk in which the granules were suspended were added to the cultured buttermilk.

Since this method of making granuled buttermilk was found to be superior in freedom from wheying off, appearance, dispersion of granules, and flavor, it was used for preparing the product for all the following experiments.

In commercial practice the cultured buttermilk might well be added directly to the churn containing the granules and the buttermilk and thoroughly mixed. However, as only small quantities of the granuled buttermilk were made up at a time in this experiment it was thought best to add the granules to the cultured buttermilk rather than the reverse order.

The Study of Granuled Buttermilk

Three liters of sweet cream testing 12 per cent butter fat were obtained from the college creamery, and churned in a six quart Dazey churn. The cream was adjusted to a churning temperature of 50° to 60° F. Enough butter color was added to give the granules a dark yellow shade. As soon as the cream broke and the granules reached the size of clover seed, the churn and contents were placed in the refrigerator, at 40° F., and allowed to remain there until the granules were quite firm. Churning was then continued until the granules reached their maximum size, without losing their

individuality. This size was comparable to small wheat kernels. Great care was exercised not to churn too long, or the granules tended to collect and mat together. As soon as the granules had reached their maximum size, the granules and the buttermilk were poured into two large beakers and transferred to the refrigerator at 40° F., where they were held until used.

A six quart Dazey churn was used for mixing the cultured buttermilk and the granules. Three quarts of the bulk culture, as made in the college creamery,were placed in the churn. The temperature of the culture was 40° F. A definite amount of granules was weighed into an aluminum cup, excluding as much buttermilk from the granules as possible, without mashing them. A small amount of the cultured buttermilk was poured into the aluminum cup containing the granules. This mixture was then transferred to the churn. The cultured buttermilk and the granules were mixed for two minutes, great care being taken to avoid undue agitation. The granuled buttermilk thus obtained was placed in pint bottles and transferred to the refrigerator where they were held at 40° F. until examined.

The acidity of the granuled product was determined in the same manner as that used for the cultured and churn buttermilk.

When cream was added, pasteurized, sweet cream, testing 20 per cent and 40 per cent butter fat, was used. The cream was added to the granuled buttermilk at the time of mixing the granules and bulk culture in the Dazey churn. Pint samples containing various percentages of cream were placed in the refrigerator at 40° F., held for 24 and 48 hours, and then removed and examined for flavor.

When studying the effect of holding temperature on granule dispersion, five lots of clean, pint bottles were filled with granuled buttermilk for

observation. The viscosity and acidity of the buttermilk were then determined. Each lot was exposed to a different temperature for two hours. The temperatures used were 65°, 70°, 80°, and 85° F. After the elapse of two hours, the bottles were examined and the results, as to the effect on granule dispersion, noted.

Two hundred and fifty cc. samples of granuled buttermilk were made up containing different amounts of granules, and placed in half pint bottles for later scoring. These bottles were then placed in the refrigerator at 40° F. for 48 hours after which they were removed, examined, and judged by different members of the dairy department as to flavor and appearance. These samples were so labeled that the judges did not know the amounts of granules added to each sample. Judging was based on the amount of granules present in proportion to the amount of cultured buttermilk to give the best flavor and appearance.

The viscosity of the granuled buttermilk used was determined by a MacMichael viscosimeter. Two hundred cc. of the buttermilk at 20° F. were placed in each of five pint bottles. Enough cold water was added and mixed to each bottle to give varying degrees of granule dispersion. Viscosity determinations were then run on each sample, and the minimum and optimum viscosities yielding the best dispersion after 48 hours noted.

A quantity of bulk culture was obtained from the college creamery and divided into two parts. To the first part two per cent of granules were added, and thoroughly mixed. A 100 cc. sample was placed in a graduated cylinder and put in the refrigerator. To the second part, no granules were added. A like sample was also taken and put in the refrigerator. This

sample was to serve as the control. Both samples were removed and examined for whey after 24 and 48 hours. The results were reported in per cent whey.

Photograph

To show the result of the effect of viscosity on granule dispersion, three samples of granuled buttermilk were made up and placed in pint bottles. The butter granules were given an unusually dark color by adding four cc. of butter color per pint sample. These samples were so made and arranged that number one would show complete dispersion, indicating high viscosity, number two less viscosity and poorer dispersion and number three the effects of very poor or low viscosity. The samples were placed on a laboratory table with a green blotter serving as a back ground. The picture was taken by the college photographer.

RESULTS

Before starting this work on granuled buttermilk it was thought best that several samples of cultured and churn buttermilk should be examined and some of their physical and chemical properties determined. The properties of the two products could then be compared and their differences noted. Such an analysis would serve more or less as a guide in formulating a good quality granuled buttermilk.

STUDY OF CULTURED BUTTERMILK

Samples from ten lots of cultured buttermilk were obtained from the college creamery and analyzed according to the methods outlined above. The results are presented in Table I. With the exception of samples number one, six, and nine all the samples were quite uniform, both in composition and physical properties. Samples one and nine showed a considerable difference in the property of wheying off, especially number one, which wheyed off to the extent of 16 per cent after 72 hours. The number nine sample was much better, showing only 2 per cent whey after a similar period of time. The wheying off which occurred in the other samples was negligible.

The fat content ranged from 0.16 to 0.36 with an average of 0.271 per cent butter fat. The range in total solids was quite narrow, being from 8.42 to 8.92 with an average of 8.659 per cent. The acidity showed a rather wide variation, ranging from a high of 0.92 to a low of 0.78 per cent, the average being 0.865 per cent.

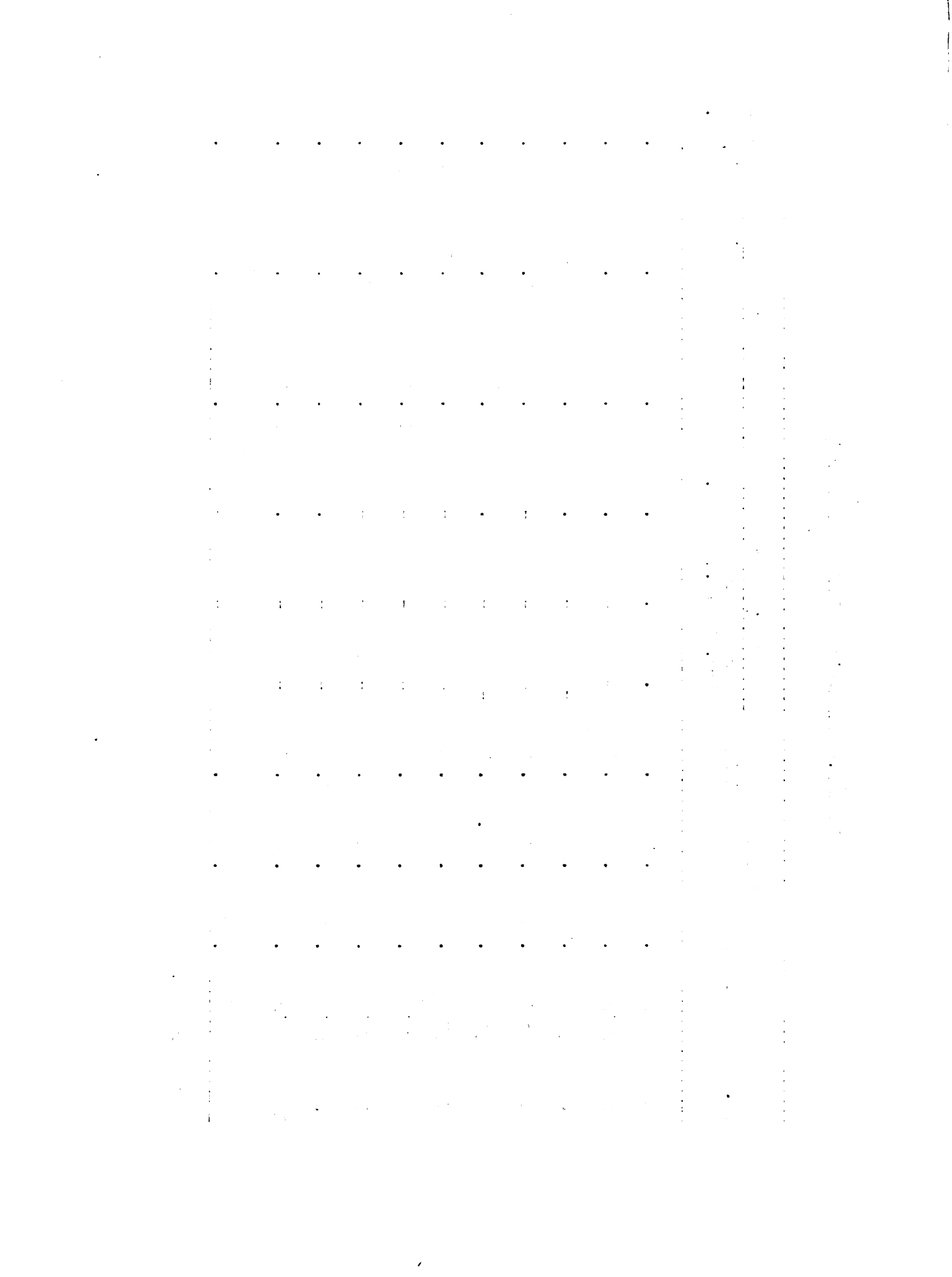
There was a great difference between the samples in the size of the curd particles, as determined both by the Knaysi and by the cheese cloth methods. Viscosity also showed a large variation, varying from 20.86 to 256.2 with an average of 158.68 centipoises.

The flavor in sample number one was poor, being thin and watery. The other samples with the exception of number six, which was exceedingly lumpy and rather flat, had no objectionable off flavors.

Table I. Analysis of Cultured Buttermilk

Sample No.	Flavor	Fat %	Total Solids %	Acidity %	Whey Off %			Size of Casein Particles		Viscosity 20° C. Centipoises
					After 24 hrs.	After 48 hrs.	After 72 hrs.	Retained on Cheese Cloth %	Knaysi Method %	
1*	poor	0.28	8.42	0.85	7.0	12.0	16.0	62.51	2.88	20.86
2	fair	0.28	8.89	0.87	-	-	0.2	72.63	2.77	123.7
3	good	0.29	8.92	0.88	-	-	0.1	32.46	-	195.1
4	good	0.31	8.56	0.92	-	-	-	2.54	0.55	190.7
5	good	0.36	8.60	0.87	-	-	0.1	4.85	0.25	174.1
6	flat lumpy	0.32	8.55	0.91	-	-	-	87.28	6.58	256.2
7	fair	0.19	8.79	0.78	-	-	-	16.58	1.88	101.4
8	fair	0.31	8.71	0.85	-	-	-	17.37	4.75	112.1
9	fair	0.16	8.52	0.88	-	-	2.0	32.61	12.84	107.2
10	fair	0.21	8.63	0.84	-	-	0.1	27.45	8.32	117.7
Average		0.271	8.659	0.865	-	-	-	35.624	4.08	158.68

* 72 hours old.



STUDY OF CHURN BUTTERMILK

In the study of the churn product samples of buttermilk from 15 separate churnings were analyzed. The results, which are presented in Table II, were fairly uniform. The cream from which the butter was churned had an average acidity of .259 per cent, whereas the resulting buttermilk averaged .248 per cent acidity.

The chief flavor defects in the churn product were classified as neutralizer and flat. The per cent of fat and of total solids present, .759 and 8.70 respectively, were comparable with those obtained by other investigators, (8), (23). Wheying off occurred in every sample without exception, and increased in amount as the product became older. The size of the casein particles varied somewhat, but were considerably smaller than those examined from the cultured product. The specific gravity showed quite a variation, varying from 1.0230 to 1.0290 with an average of 1.0255. There was only a slight variation in the viscosities, the average being 2.054 centipoises.

Table II. Analysis of Churn Buttermilk

Sample No.	Cream Acidity %	Flavor	Acidity %	Fat %	Total Solids %	Whey Off % After 24 hrs.	After 48 hrs.	After 72 hrs.
1	0.21	Slight neutraillizer	0.20	0.60	8.23	5	8	11
2	0.30	Flat buttery	0.29	0.71	8.48	11	17	31
3	0.25	Good	0.23	0.61	8.52	15	26	34
4	0.36	Slight neutralizer	0.34	0.60	8.87	26	37	44
5	0.18	Flat	0.17	0.68	8.98	10	17	24
6	0.21	Flat	0.18	0.74	8.95	9	16	25
7	0.26	Slight Neutralizer	0.24	0.80	8.44	8	13	16
8	0.20	Slightly buttery	0.18	0.71	8.49	11	17	23
9	0.21	Fair	0.20	0.89	8.89	11	25	36
10	0.47	Good	0.47	0.92	8.64	3	5	8
11	0.31	Good	0.30	0.88	8.85	6	12	15
12	0.21	Neutralizer and buttery	0.22	0.80	8.58	9	18	26
13	0.22	Flat	0.22	0.75	8.77	8	17	24
14	0.32	Fair	0.30	0.77	8.92	3	4	5
15	0.18	Strong neutralizer	0.18	0.89	8.94	13	21	29
Average	0.259		0.248	0.759	8.70	9.8	17.6	23.4

Table II. (Continued) Analysis of Churn Buttermilk

Sample No.	Size of Casein Particles					Specific Gravity 15° C.	Viscosity 20° C. Centi-poises
	Clusters %	Particles %	Size Range Microns	Average Size Microns	Retained on Cheese Cloth %		
1	79.12	20.88	3 - 78	28	7.85	1.0290	2.052
2	81.36	18.64	4 - 80	34	12.32	1.0250	2.001
3	77.33	22.67	5.- 50	25	4.84	1.0257	1.950
4	73.61	26.39	2 - 75	18.5	8.34	1.0248	2.115
5	88.00	12.00	2.5 - 80	25	10.62	1.0270	2.008
6	93.00	7.00	1.5 - 110	17	10.07	1.0270	2.118
7	82.00	18.00	3 - 60	21	1.74	1.0260	1.964
8	86.01	13.99	5 - 112	25	3.86	1.0254	2.105
9	88.89	11.11	5 - 87	28	5.85	1.0276	2.106
10	84.26	15.74	5 - 90	18	4.49	1.0257	1.861
11	81.34	18.66	4 - 94	21	3.25	1.0263	2.115
12	70.89	29.11	4 - 50	10	4.04	1.0240	2.011
13	68.34	21.66	3 - 89	19	3.64	1.0257	2.318
14	78.44	21.56	3 - 50	8	2.30	1.0253	2.206
15	70.23	29.77	4 - 79	10	3.87	1.0230	1.913
Aver-age	80.18	19.14	3.6 - 78.9	20.5	5.80	1.0255	2.054

COMPARISON OF CULTURED AND CHURN BUTTERMILK

The differences between the cultured and churn buttermilk were very marked in all the properties examined, except in case of the per cent of total solids. The per cent of total solids of each buttermilk was similar, the average being 8.659 per cent for the cultured buttermilk and 8.70 per cent for the churn buttermilk.

The flavor of the cultured product differed markedly from that of the churn buttermilk. The former was characterized by its acidity and pleasantness, whereas the latter often possessed buttery and neutralizer flavors.

The contrast in the fat and acidity content was very marked between the two buttermilks. The cultured buttermilk had an average fat content of 0.271 per cent and an acidity of 0.865 per cent, while the churn buttermilk averaged 0.759 per cent fat and 0.248 per cent acidity.

Wheying off occurred in the churn buttermilk after 24 hours without exception, and increased as the product became older. However, in the cultured product, except sample number one, wheying off did not occur during the first 48 hours, and only two samples, numbers one and nine, showed any appreciable amount of whey after 72 hours.

The size of the casein particles found in the two buttermilks, as determined by the cheese cloth method, also showed a marked contrast. The particles of cultured buttermilk retained on the cheese cloth averaged 35.624 per cent and that of the churn product only 5.80 per cent.

The difference between the viscosities of the two products was considerable. The average for the cultured buttermilk was 158.68 centipoises

while that of the churn buttermilk was much lower, being only 2.054 centipoises.

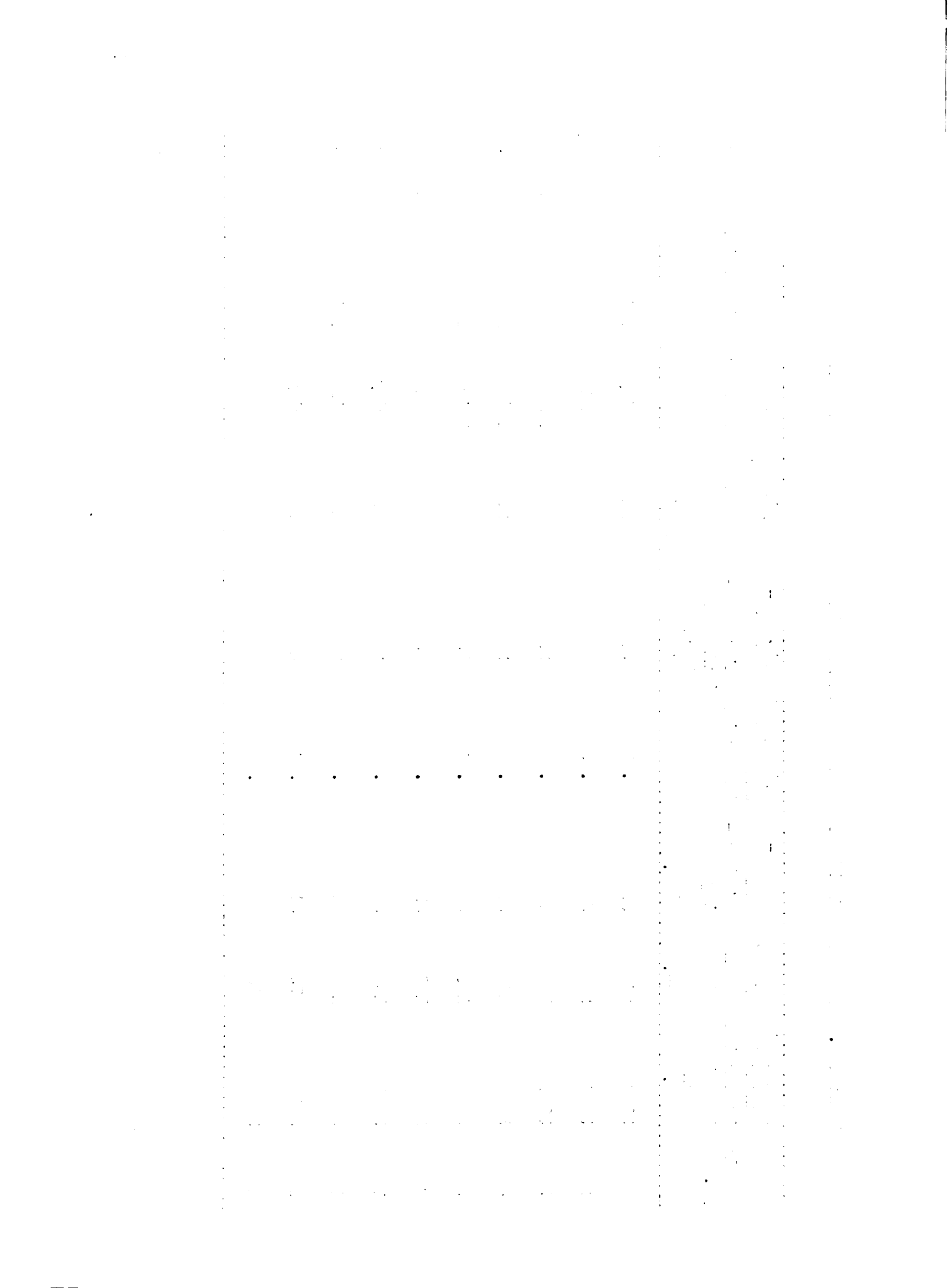
THE MAKING OF GRANULED BUTTERMILK BY THE CHURN METHOD

In all the experiments in which granuled buttermilk was made by the churn method, unsatisfactory results were obtained. Excessive wheying off occurred in every case, probably due to the excessive agitation and prolonged time required to produce the granules. The granules obtained by this method were flaky, small, and comparatively inconspicuous.

The flavor immediately after churning showed some superiority over the original cultured milk, but rapidly deteriorated after the sample had been held for a few hours. The granules, however, which were obtained by this method, seemed to have greater individuality than those obtained and used in the addition method. The dispersion of these granules was quite good. The results are shown in Table III.

Table III. RESULTS OBTAINED IN MAKING GRANULED BUTTERMILK BY THE CHURN METHOD

Sample No.	Amount of Cultured Buttermilk Used in Churn cc.	Amount of 40% Cream Added cc.	Temperature of Churning °F.	Acidity of Cultured Buttermilk %	Time Required for Granules to Form Minutes	Wheying Off after 48 hours %	Flavor after 24 hours	Dispersion	Appearance
1	5000	250	50	0.87	55	11	Acidy	Fair	
2	5000	200	50	0.85	50	18	Flat	Good	
3	5000	150	60	0.85	25	18	Flat	Good	Granules
4	5000	150	58	0.82	28	20	Fair	Fair	Small,
5	5000	125	55	0.84	35	14	Fair	Good	Flaky
6	5000	100	53	0.84	45	14	Flat	Good	and
7	5000	100	58	0.85	28	8	Acidy	Good	Rather
8	5000	100	60	0.84	20	12	Fair	Fair	Incon-
9	5000	75	54	0.86	40	30	Acidy	Good	spicuous
10	5000	75	58	0.83	32	18	Flat	Good	



MAKING GRANULED BUTTERMILK BY THE GRANULE ADDITION METHOD

All the results of the experiments in making granuled buttermilk by the granule addition method were highly satisfactory and proved much superior in every detail to those obtained by the churning method. Whey-ing off was not encountered, except where the original cultured buttermilk was of inferior quality. The appearance was good. The granules were of sufficient size to be seen readily when the product was bottled. The flavor was improved in every case, the granules being of sufficient size to be tasted easily. The results are presented in Table IV.

Preserving the individuality of the butter granules before adding them to the churn presented some difficulties in this method. Freezing the granules at temperatures below zero rather than hardening them at 40° F. did not prove entirely satisfactory. Two different lots of granules, containing as little buttermilk as possible were hardened at low tempera-tures for two hours, after which they were added to the cultured butter-milk. The granules were firm, but matted together so strongly that it was most difficult to distribute them evenly and disperse them as individual granules throughout the cultured buttermilk. This method of hardening the granules was, therefore, discontinued.

Table IV. RESULTS OBTAINED IN MAKING GRANULED BUTTERMILK BY THE GRANULE ADDITION METHOD.

Sample No.	Amount of Cream Used cc.	Fat Test of Cream %	Churning Temperature ° F.	Time Required to Obtain Granules Minutes	Time Left in Refrigerator 40° F. Hours	Amount of Cultured Buttermilk cc.	Amount of Granules Added grams	Amount of Granules Added %	Wheying Off After 48 Hours %	Flavor	Dispersion	Appearance
1	3000	12.0	55	25	2	2200	42	1.9	None	Slightly Buttery	Fair	Slightly too many granules
2	3000	12.0	60	20	2	2000	20	1.0	None	Fair	Good	Good
3	3000	12.0	58	20	2	1500	15	1.0	None	Good	Good	Good
4	3000	12.0	55	28	2	1000	10	1.0	None	Fair	Good	Good
5	3000	12.0	56	30	2	1000	12	1.2	None	Good	Good	Good
6	3000	12.0	60	18	2	1000	15	1.5	.1	Slightly Buttery	Good	Slightly too many granules
7	3000	12.0	58	22	2	1000	10	1.0	None	Good	Good	Good
8	3000	12.0	62	16	2	750	8	1.1	None	Good	Good	Good
9	3000	12.0	59	17	2	500	6	1.2	None	Fair	Good	Good
10	3000	12.0	63	14	2	500	5	1.0	None	Good	Good	Good

EFFECT OF DIFFERENT VISCOSITIES ON THE GRANULE DISPERSION

The viscosity of the cultured buttermilk seemed to have an important bearing on whether the butter granules stayed evenly distributed or came to the top of the container. This experiment was undertaken to ascertain the minimum viscosity at which the granules would stay evenly dispersed, and further, to determine the most desirable viscosity in the cultured buttermilk to maintain even granule distribution. The results of these experiments are presented in Table V.

It was found that, when the viscosity of the cultured buttermilk dropped below 50 centipoises, the granule dispersion was poor, which meant that the greater portion of the granules had collected at the top of the container. The lowest viscosity at which the granules would stay dispersed was classified as "barely satisfactory". Viscosities from 65.56 to 74.50 centipoises gave results classified as "fair". Viscosities above 74.50 centipoises proved to be ideal both from the standpoint of even distribution and from the maintenance of the proper degree of dispersion of the granules. It was also noted that average cultured buttermilk having an acidity of .80 per cent, or over, and not diluted in any way, always gave a viscosity sufficiently high to insure the maximum granule dispersion.

Table V. THE EFFECT OF DIFFERENT VISCOSITIES ON THE GRANULE DISPERSION

Number of Lot	Acidity of Granuled Buttermilk %	Size of Sample of Granuled Buttermilk cc.	Viscosity of the Granuled Buttermilk Cp.	Amount of Water Added to each Sample cc.	Amount of Water Added to each Sample %	Viscosity After Addition of Water Cp.	Dispersion
I	0.84	200	333.76	None	None	333.76	Very good
	0.84	200	333.76	50	25.0	74.50	Fair
	0.84	200	333.76	75	37.5	47.68	Poor
	0.84	200	333.76	85	42.5	44.70	Poor
	0.84	150	333.76	100	60.6	23.84	Very poor
II	0.81	200	238.40	None	None	238.40	Very good
	0.81	200	238.40	30	15.0	83.44	Good
	0.81	200	238.40	40	20.0	74.50	Fair
	0.81	200	238.40	45	27.5	65.56	Barely satisfactory
III	0.85	200	220.52	None	None	220.52	Very good
	0.85	200	220.52	25	12.5	134.10	Very good
	0.85	200	220.52	30	15.0	104.30	Very good
	0.85	200	220.52	35	17.5	98.34	Very good
	0.85	200	220.52	40	20.0	86.42	Good
IV	0.83	200	226.48	None	None	226.48	Very good
	0.83	200	226.48	25	12.5	154.96	Very good
	0.83	200	226.48	30	15.0	113.24	Very good
	0.83	200	226.48	35	17.5	98.34	Very good
	0.83	200	226.48	40	20.0	89.40	Good
	0.83	200	226.48	45	22.5	74.50	Fair
	0.83	200	226.48	50	25.0	65.56	Barely satisfactory

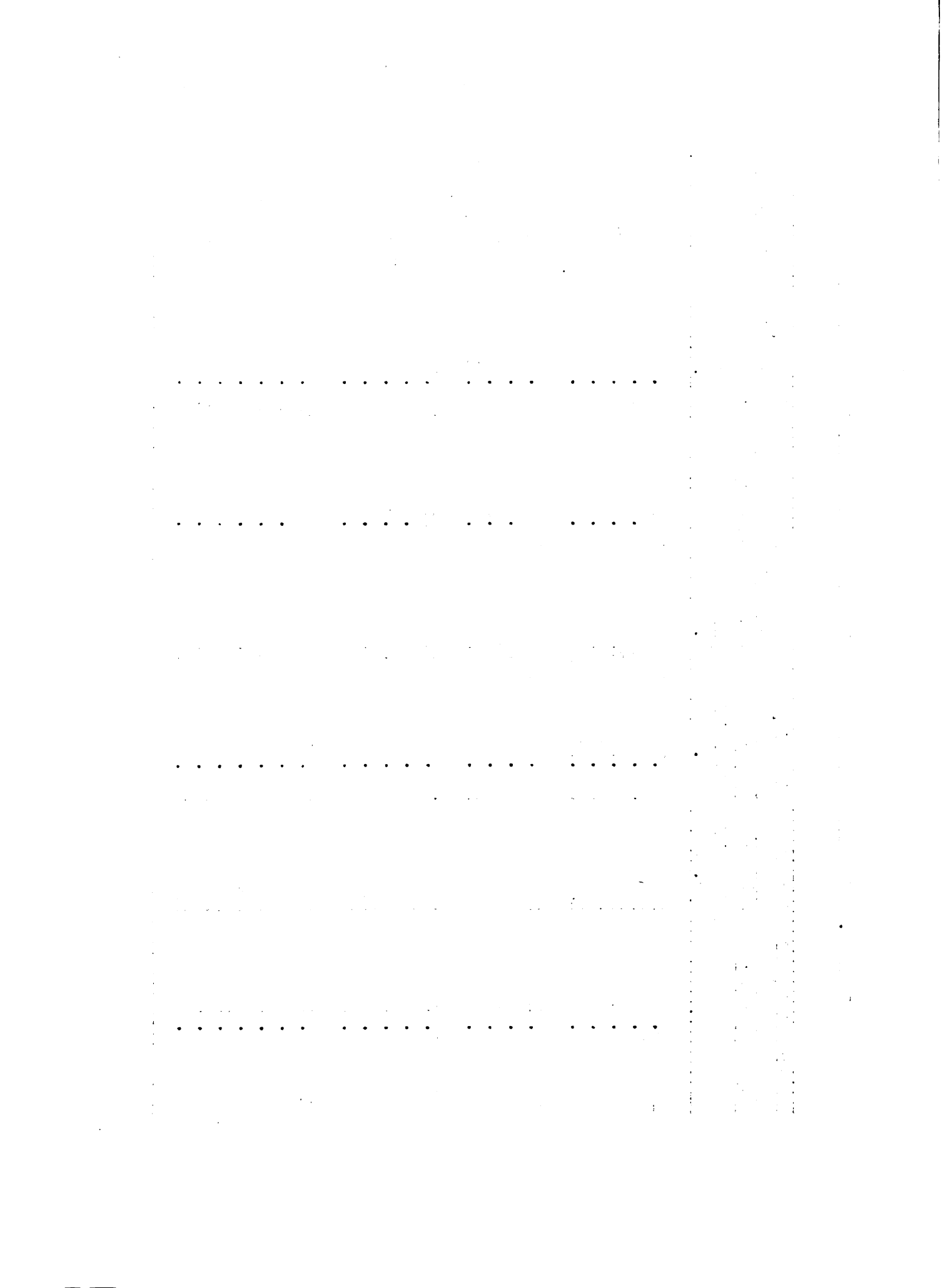


Table V. (Continued) THE EFFECT OF DIFFERENT VISCOSITIES ON THE GRANULE DISPERSION

Number of Lot	Acidity of Granuled Buttermilk %	Size of Sample of Granuled Buttermilk cc.	Viscosity of the Granuled Buttermilk Cp.	Amount of Water added to each Sample cc.	Amount of Water Added to each Sample %	Viscosity After Addition of Water Cp.	Dispersion
V	0.82	200	242.40	None	None	242.40	Very good
	0.82	200	242.40	30	15.0	105.44	Very good
	0.82	200	242.40	40	20.0	91.32	Good
	0.82	200	242.40	45	22.5	80.30	Fair
	0.82	200	242.40	50	25.0	67.82	Barely satisfactory

EFFECT OF BUTTER GRANULES ON THE WHEYING OFF OF GRANULED BUTTERMILK

Any type of artificially made buttermilk is unsatisfactory if wheying off occurs within 48 hours. It has been shown (8) (15) that cultured buttermilk will remain free from this defect for more than 48 hours if good quality materials are used in the making, and if the product is kept at temperatures below 45° F. Trials were run, therefore, to see whether the butter granules, as added to cultured buttermilk would have any effect on wheying off. The results are given in Table VI.

It would appear from these results that the presence of butter granules does not effect the separation of whey. Of the samples examined only one, number five, gave any appreciable amount of whey. However, the control sample remained free of this defect. The amounts of whey present after 48 hours in samples one, two and six were quite negligible, although present. The controls of these samples, however, were criticized for being gassy. In the other samples, neither the control nor the granuled product showed any wheying off after the 48 hour period.

Table VI. THE EFFECT OF BUTTER GRANULES ON THE WHEYING OFF OF GRANULED BUTTERMILK

	Amount of Whey % After 24 hrs. 40° F.(Control)	Amount of Whey % After 24 hrs. 40° F.	Amount of Whey % After 48 hrs. 40° F.(Control)	Amount of Whey % After 48 hrs. 40° F.
1	None	None	.1 (gassy)	.3
2	None	None	None	.2
3	None	None	None	None
4	None	None	None	None
5*	None	1.0	None	4.0
6	None	None	.2 (gassy)	.2
7	None	None	None	None
8	None	None	None	None
9	None	None	None	None
10	None	None	None	None

* This wheying off was probably due to excessive agitation rather than from the granules.

EFFECT OF VARIOUS AMOUNTS OF GRANULES ON FLAVOR AND APPEARANCE

Flavor and appearance are two of the most desirable qualities to be controlled in making granuled buttermilk. The flavor must be clean, pleasant and resemble churn buttermilk to a considerable degree. The granules must be of such size that they may be readily seen in the bottle or container, and easily tasted when the product is taken into the mouth. With these facts in mind, this phase of the work was undertaken to determine the most desirable amount of butter granules that should be added, to give the buttermilk these desired qualities.

From the data presented in Table VII, it appears that even as little as two tenths of one per cent of butter granules, when added to the cultured buttermilk, gave some improvement in flavor. This improvement in flavor increased until one per cent of granules had been added. Additions of granules above one per cent gave too large a proportion of granules to the amount of cultured buttermilk present. Furthermore, when more than one per cent was added the flavor also tended to become buttery.

When the granules were added in increasing amounts below five tenths of one per cent the flavor was somewhat improved, but the granules were quite inconspicuous and not readily seen. When amounts above one per cent were added, both the flavor and appearance were affected, the flavor becoming slightly buttery and the appearance being criticized for having too many granules present.

Of all the samples judged, those containing six tenths to one per cent of granules gave the best results from a flavor standpoint. From the point

of view of appearance, the addition of only six tenths of one per cent of granules gave fair results, there being scarcely enough granules present to be seen readily. The best results were obtained when eight tenths to one per cent were used.

Table VII. THE EFFECT OF VARIOUS AMOUNTS OF GRANULES ON FLAVOR AND APPEARANCE

Lot No.	Amount of Cultured Buttermilk cc.	Amount of Granules Added grams	Amount of Granules Added %	Flavor	Granule Appearance
I	250	Control	-	Good	
	250	0.5	0.2	No improvement	Inconspicuous
	250	1.0	0.4	Slight improvement	Inconspicuous
	250	1.5	0.6	Good	Fair
	250	2.0	0.8	Very good	Good
II	250	Control	-	Good	
	250	0.5	0.2	No improvement	Inconspicuous
	250	1.0	0.4	Slight improvement	Inconspicuous
	250	1.5	0.6	Good	Fair, hardly enough granules
	250	2.0	0.8	Very good	Good
	250	2.5	1.0	Very good	Good
III	250	Control	-	Good	
	250	1.5	0.6	Considerable improvement	Fair
	250	2.0	0.8	Good	Good
	250	2.5	1.0	Good	Good
	250	3.0	1.2	Slightly buttery	Slightly too many granules

TABLE VII. (Continued) THE EFFECT OF VARIOUS AMOUNTS OF GRANULES ON FLAVOR AND APPEARANCE

Lot No.	Amount of Cultured Buttermilk cc.	Amount of Granules Added grams	Amount of Granules Added %	Flavor	Granule Appearance
IV	250	Control	-	Good	
	250	2.0	0.8	Good	Good
	250	3.0	1.2	Fair	Slightly too many granules
	250	4.5	1.8	Slightly buttery	Too many granules
	250	5.0	2.0	Poor, buttery	Too many granules
	250	6.0	2.4	Very buttery	Too many granules
	250	7.0	2.8	Very buttery	Too many granules
	250	8.0	3.2	Very buttery	Too many granules
V	250	Control	-	Good	
	250	3.0	1.2	Good	Good
	250	4.5	1.8	Slightly buttery	Too many granules.
	250	5.0	2.0	Poor, buttery	Too many granules.
	250	6.0	2.4	Very buttery	Too many granules
	250	7.0	2.8	Very buttery	Too many granules
	250	8.0	3.2	Very buttery	Too many granules.
VI	250	Control	-	Good	
	250	1.5	0.6	Considerable improvement	Fair
	250	2.0	0.8	Good	Good
	250	2.5	1.0	Good	Good
	250	3.0	1.2	Slightly buttery	Slightly too many granules

EFFECT UPON GRANULE DISPERSION OF DIFFERENT TEMPERATURES OF MIXING AND STORING GRANULED BUTTERMILK

From the previous experiments, it was observed that with a rise in temperature there was a decrease in the viscosity of the buttermilk. Furthermore, as previously stated, a viscosity of 65.56 centipoises was the lowest at which the granules would stay dispersed with any degree of success. In view of these observations, trials were made to see if the high temperatures, as encountered in the summer months, would reduce the viscosity of the cultured buttermilk to such an extent, that special precautions in temperature regulation would be necessary in order to insure having a viscosity sufficiently high to give the granules the proper degree of dispersion.

The results obtained, presented in Table VIII, show that temperatures from 65 to 85° F. for two hours can be used satisfactorily in mixing the granules with cultured buttermilk and storing the product without materially injuring the dispersion properties. It was also found that the lower temperatures gave the best results. A temperature of 85° F. for mixing gave fairly good results, but not so good as when lower temperatures were used. After the sample had stood for a few minutes at this high temperature, the granules had a tendency to soften and mat together. There was also a tendency for the granules to be in the upper half of the container. This last defect, however, was not serious enough to make the sample entirely unsatisfactory. Although these comparatively high temperatures appeared satisfactory in part at least, from the standpoint of granuled dispersion, bacterial development continued which affected the flavors.

Table VIII. THE EFFECT UPON GRANULE DISPERSION OF DIFFERENT TEMPERATURES OF MIXING AND STORING GRANULED BUTTERMILK

Lot No.	Amount of Granuled Buttermilk cc.	Acidity of Granuled Buttermilk %	Viscosity of Granuled Buttermilk Cp.	Temperatures Held - 2 hrs. ° F.	Gramule Dispersion After 2 hrs.
I	500	0.83	128.14	65	Very good
	500	0.83	128.14	70	Very good
	500	0.83	128.14	75	Good
	500	0.83	128.14	80	Good
	500	0.83	128.14	85	Fairly good
II	500	0.86	154.96	65	Very good
	500	0.86	154.96	70	Very good
	500	0.86	154.96	75	Very good
	500	0.86	154.96	80	Good
	500	0.86	154.96	85	Good
III	500	0.81	113.24	65	Very good
	500	0.81	113.24	70	Very good
	500	0.81	113.24	75	Good
	500	0.81	113.24	80	Good
	500	0.81	113.24	85	Fair

Table VIII. (Continued) THE EFFECT UPON GRANULE DISPERSION OF DIFFERENT TEMPERATURES OF MIXING AND STORING GRANULED BUTTERMILK

Lot No.	Amount of Granuled Buttermilk cc.	Acidity of Granuled Buttermilk %	Viscosity of Granuled Buttermilk Cp.	Temperatures Held - 2 hrs. ° F.	Granule Dispersion After 2 hrs.
IV	500	0.82	121.36	65	Very good
	500	0.82	121.36	70	Very good
	500	0.82	121.36	75	Very good
	500	0.82	121.36	80	Good
	500	0.82	121.36	85	Fairly good
V	500	0.83	132.40	65	Very good
	500	0.83	132.40	70	Very good
	500	0.83	132.40	75	Very good
	500	0.83	132.40	80	Good
	500	0.83	132.40	85	Good
VI	500	0.80	118.32	65	Very good
	500	0.80	118.32	70	Very good
	500	0.80	118.32	75	Good
	500	0.80	118.32	80	Fairly good
	500	0.80	118.32	85	Fair

EFFECT OF THE ADDITION OF DIFFERENT AMOUNTS OF CREAM ON THE FLAVOR OF GRANULED BUTTERMILK

The addition of small amounts of cream to buttermilk is not new. Several investigators (9), (20), have recommended its use as a means of improving the flavor of cultured buttermilk. Numerous trials were made to determine the effect which small additions of cream would have upon the flavor of the granuled buttermilk.

In the first seven lots, various amounts of 40 per cent, pasteurized, sweet cream were added to the granuled buttermilk. The results are shown in Table IX. In lots one, two, three and seven, the flavor of the base cultured buttermilk as represented by the control was slightly off. However, when amounts of cream from one to three per cent were added, this off flavor was more or less masked with the result that a better flavored product was obtained. The most marked improvement from all standpoints occurred when one and five tenths to two per cent of cream were used. It appeared that no additional flavor advantage was obtained by adding over two per cent of cream to the granuled buttermilk when the flavor of the original buttermilk was somewhat off, or the acid slightly high.

In lots four, five and six, the base, or control, buttermilk was of good flavor. When two to three per cent of 40 per cent cream were added, the flavor was not improved, but became somewhat unnatural, being criticized for being slightly rich and creamy. When amounts from one to one and one-half per cent were added, slight, if any, changes were noticed.

Table IX. EFFECT OF THE ADDITION OF DIFFERENT AMOUNTS OF CREAM ON THE FLAVOR OF GRANULED BUTTERMILK

Lot No.	Amount of 40% Cream % by Volume	Acidity of Granuled Buttermilk %	Age of Sample when examined for Flavor hours	Flavor
I	Control	0.82	48	Flat
	1.0	0.82	48	Slightly flat
	2.0	0.82	48	Good
	3.0	0.82	48	Fair
II	Control	0.84	48	Very poor
	1.0	0.84	48	Poor
	2.0	0.84	48	Fair
	3.0	0.84	48	Fair
III	Control	0.85	48	Too acid, poor
	1.0	0.85	48	Fair
	1.5	0.85	48	Fair
	2.0	0.85	48	Fair
IV	Control	0.83	24	Good
	1.5	0.83	24	Slightly better
	2.0	0.83	24	Good
	2.5	0.83	24	Good
	3.0	0.83	24	Slightly rich

Table IX. (Continued) EFFECT OF THE ADDITION OF DIFFERENT AMOUNTS OF CREAM ON THE FLAVOR OF GRANULED BUTTERMILK

Lot No.	Amount of 40% Cream % by Volume	Acidity of Granuled Buttermilk %	Age of Sample when Examined for Flavor hours	Flavor
V	Control	0.81	24	Fair
	1.0	0.81	24	Slightly better
	1.5	0.81	24	Slightly better
	2.0	0.81	24	Too creamy
VI	Control	0.78	24	Good
	1.0	0.78	24	Good
	1.5	0.78	24	Good
	2.0	0.78	24	Slightly too rich
VII	Control	0.74	24	Fair
	1.0	0.74	24	Good
	1.5	0.74	24	Good
	2.0	0.74	24	Slightly rich
VIII	Control	0.82	24	Good
	1.0	0.82	24	Good (Slightly better)
	1.5	0.82	24	Good
	2.0	0.82	24	Slightly rich

EFFECT ON THE FLAVOR BY THE ADDITION OF 20 PER CENT VERSUS 40 PER CENT CREAM TO GRANULED BUTTERMILK

Trials were made to determine if the use of 20 per cent cream would give results comparable to the results obtained when 40 per cent cream was added to granuled buttermilk, providing equal amounts of fat were used. The results are shown in Table X.

A total of six lots were examined. Lots one, two, four, and six gave identical results, in that there was no flavor difference when either 20 per cent or 40 per cent cream was added to the granuled buttermilk. In lots three and five, there was only a slight flavor difference, but this flavor was not magnified enough for the average consumer to detect.

The addition of small amounts of cream in lots one, two, three and six improved the flavor. The controls of these samples were somewhat off flavored. In lots four and five, the control samples were good flavored and the addition of small amounts of cream had little or no effect on the flavor.

Table X. EFFECT ON THE FLAVOR BY THE ADDITION OF 20 PER CENT VERSUS 40 PER CENT CREAM TO GRANULED BUTTERMILK

Lot No.	Amount of 20% Cream % Volume	Amount of 40% Cream % Volume	Acidity of Granuled Buttermilk %	Age of Sample when Examined for Flavor hours	Flavor	
I	Control	Control	0.80	24	Poor	
	None	1.5	0.80	24	Good)	
						)no difference
	3.0	None	0.80	24	Good)	
	None	1.0	0.80	24	Fair)	
						)no difference
	2.0	None	0.80	24	Fair)	
II	Control	Control	0.81	24	Poor, flat	
	None	1.5	0.81	24	Fairly good)	
						)no difference
	3.0	None	0.81	24	Fairly good)	
	None	1.0	0.81	24	Fair)	
						)no difference
	2.0	None	0.81	24	Fair)	
III	Control	Control	0.84	24	Fair, slightly acidy	
	None	1.5	0.84	24	Good +	
	3.0	None	0.84	24	Good	
	None	1.0	0.84	24	Fair)	
						)no difference
	2.0	None	0.84	24	Fair)	

Table X. (Continued) EFFECT ON THE FLAVOR BY THE ADDITION OF 20 PER CENT VERSUS 40 PER CENT CREAM TO GRANULED BUTTERMILK

Lot No.	Amount of 20% Cream % Volume	Amount of 40% Cream % Volume	Acidity of Granuled Buttermilk %	Age of Sample when Examined For Flavor hours	Flavor
IV	Control	Control	0.83	48	Good
	None	1.5	0.83	48	Good))no difference
	3.0	None	0.83	48	Good)
	None	1.0	0.83	48	Good))no difference
	2.0	None	0.83	48	Good)
V	Control	Control	0.82	48	Godd
	None	1.5	0.82	48	Slightly better
	3.0	None	0.82	48	Slightly better
	None	1.0	0.82	48	Good +
	2.0	None	0.82	48	Good
VI	Control	Control	0.81	48	Fair
	None	1.5	0.81	48	Good))no difference)
	3.0	None	0.81	48	Good)
	None	1.0	0.81	48	Fair))no difference
	2.0	None	0.81	48	Fair)

EFFECT OF SIZE OF GRANULES ON DISPERSION

The size of the butter granules usually present in granuled buttermilk may be roughly classed under two headings, namely, those comparable to the size of clover seed, and those approaching the size of small kernels of wheat. The former are found chiefly in granuled buttermilk made by the churn method, while the latter are most common in the product when the granule addition method is used.

The smaller granules, as obtained by the churn method, proved to be slightly better in staying evenly dispersed, than the granules the size of small wheat kernels. However, the dispersion of the granules of either size were such, as to be considered entirely satisfactory.

When granules from an average commercial churning of butter were added to cultured buttermilk the dispersion was fair, but not as good as when the smaller sized granules were added. These granules were somewhat larger than any found in granuled buttermilk, and were comparable in size to plump wheat kernels.

It appeared that the larger the granules the greater would be the buoyancy and the greater the tendency toward inferior dispersion. However, the granules as ordinarily obtained in the churning method or those used in the granule addition method were not of sufficient size to cause faulty dispersion. The granules as obtained from the average commercial churning may be disregarded as far as granuled buttermilk was concerned owing to the difficulty of obtaining them as individual granules. The size of these granules were also such, that flavor and appearance were impaired, being too large when taken into the mouth, and giving the product a more or less chunky appearance.

Table XI. EFFECT OF SIZE OF GRANULES ON DISPERSION

Sample No.	Amount of Cultured Buttermilk Used cc.	Acidity of Cultured Buttermilk %	Amount of Granules Added %	Comparable Size of Granules	Appearance	Dispersion
1	250	0.84	1.0	Clover seed	Fair	Very good
2	250	0.82	1.0	Clover seed	Fair	Very good
3	250	0.81	1.0	Clover seed	Fair	Very good
4	250	0.83	1.0	Clover seed	Fair	Very good
5	250	0.83	1.0	Small wheat kernels	Very Good	Good
6	250	0.86	1.0	Small wheat kernels	Very good	Good
7	250	0.81	1.0	Small wheat kernels	Very good	Good
8	250	0.82	1.0	Small wheat kernels	Very good	Good
9	250	0.85	1.0	Small corn kernels	Granules too large, gave a chunky appearance	Fair
10	250	0.84	1.0	Small corn kernels		Fair
11	250	0.84	1.0	Small corn kernels		Fair

DISCUSSION

The average analysis of the cultured buttermilk represented quite closely the usual composition of this product. There were, however, some of the samples that appeared abnormal. The high percentage of wheying off encountered in sample one was due to age. This sample was 72 hours old before being analyzed, while the remaining samples were less than 24 hours old.

The variation in the amount of fat and of total solids is rather hard to explain unless the skimmilk from which the product was made varied to some degree in its composition, due to the incompleteness of skimming, high pasteurizing and holding temperatures, or to the addition of water. It is doubtful if the actual manufacturing operations had any marked effect on the percentage composition.

Acidity variations may be explained by a number of factors, such as amount of inoculum, duration and temperature of incubation, and to the degree to which the product was cooled. The fact that these samples were obtained and analyzed during the warm summer months might have had some bearing on the acidity ranges.

The difference in the size of the casein particles was probably due to one or two factors, namely, the degree of ripeness, or to the method and time required to break up the coagulum. This last cause was probably the chief reason for the variation.

The viscosity variation may be closely associated with the amount of inoculum, the pasteurization exposure, and to the degree of ripeness of the coagulum. The fineness of the broken coagulum may also have caused

this variation. The low viscosity reading obtained on one of the samples was probably due to the age of the sample, and to the fact that considerable whey was present, for as shown, low viscosity is closely associated with wheying off.

The average results obtained from the study of the churn buttermilk again show considerable similarity to the usual analyses of this buttermilk. The cream used for the churnings varied in acidity, due to the degree of neutralization employed, and to the ripening period following pasteurization.

The acidity of the churn buttermilk appeared to be somewhat abnormal, in that it was somewhat lower than the acidity of the cream used. This was the reverse of what would normally be expected. Since the acidity is confined almost entirely to the serum, a concentration of the serum, therefore, should give an increase in the amount of acidity in the buttermilk, rather than a slight decrease. This reverse order probably may be explained by the fact that the serum of the cream was somewhat diluted by the water used to rinse down the cream vat. Variations in the amount of this rinse water added, may also have accounted for the variation in the specific gravity, total solids, and to the slight variation of the viscosities.

The degree of variation in the fat content of the churn buttermilk may be explained by variations in exhaustiveness of churning as influenced by many factors, such as acidity of the cream, temperature of the cream at time of churning, prolongation of churning, richness of the cream, time of holding cream at low temperatures, and so forth.

Wheying off in all the samples could be attributed chiefly to the lack of viscosity.

The variation in the size of the casein particles of the churn buttermilk was probably the result of such factors as time required to churn, acidity, fat content of cream, and to the completeness of churning.

When the churn method of making granuled buttermilk was used, wheying off occurred in every case. This defect was probably caused by too vigorous agitation and to the length of time this agitation was required before the granules became of sufficient size. The low fat content of the mixture of cream and cultured buttermilk was largely responsible for the long period required to churn. This defect may not, and probably does not occur when large amounts of the product are made, and the large factory revolving churn is used. The revolving churn has a less vigorous action, yet more of a concussion force than has the small Dazey churn which was used in these experiments.

The flavor of the granuled buttermilk made by the churn method was superior to the original for a few hours, but soon deteriorated. The fact that separation of whey occurred naturally would affect the flavor. The fresh aromatic flavor of the cultured buttermilk was replaced by a sharper acidity and a dull, almost insipid flavor.

The granules obtained by the churn method of manufacture were quite small, flaky, and rather inconspicuous. This was probably due to the small amount of fat present in the mixture of cream and cultured buttermilk from which the granuled buttermilk was made. Low testing cream usually requires

a longer churning period, other conditions remaining constant, than high testing cream, and the granules formed are generally smaller.

The granule addition method of making granule buttermilk gave a superior finished product than did the churn method. Since the granules were churned separately and then added to the cultured buttermilk, wheying off was practically eliminated. The flavor of the granuled buttermilk as made by this method was slightly inferior to the flavor obtained by the other method during the first few hours, chiefly because the duration of time was not sufficient to blend the flavor of the granules and the cultured buttermilk, which blending finally yielded the old-fashioned, churn buttermilk flavor. This flavor, once blended, improved with age, within limits, and was good even after 48 hours, while the flavor of the churn product deteriorated rapidly after the first few hours and continued to deteriorate and after 48 hours it was very inferior.

Considerable care had to be exercised in churning the granules, as a small amount of over churning tended to force the granules into a clump, or mass. In obtaining these granules a small churn which may be watched closely and regulated is quite necessary. In order to reduce the chances of the granules matting together, the entire churning was cooled after the granules had formed, after which the churning was continued until the granules reached the desired size.

Cream testing 12 per cent butterfat was used instead of a higher fat cream for obtaining the butter granules, chiefly because a high fat cream, when churned, gave too large a proportion of granules to the amount of

buttermilk present, which, therefore, increased the difficulty of maintaining the individuality of the granules.

From the viscosity studies, it was evident that the cultured buttermilk to which the granules were added, unless diluted, would always have a viscosity sufficiently high to insure good granule disperion. Water might be used to reduce the viscosity of the product, in case a less viscous product was desired as long as the viscosity is kept, preferably above 74.50 centipoises. Viscosities as low as 65.56 centipoises might be used, but if success is to be guaranteed in every day operations, it would be better to keep above the higher viscosity.

There seemed to be no apparent effect on wheying off of granuled buttermilk due to the addition of butter granules. If the agitation in mixing the granules and cultured buttermilk were excessive, wheying off was likely to occur, being caused by this agitation rather than by the presence of granules. When the cultured buttermilk used was somewhat gassy, a separation of whey was the usual result, which became greater with age.

The flavor and appearance of granuled buttermilk depended to a large extent on having the correct amount of granules present. From both standpoints eight tenths to one per cent of granules were recommended as best meeting these requirements. When more than one per cent of granules were added, the buttermilk appeared unnatural and mottled. An excess of granules also impaired the flavor, yielding a buttery flavor which was not considered beneficial.

The granules and cultured buttermilk might be mixed at temperatures as high as 85° F. but was not advisable since even distribution of the

granules was harder to maintain. The viscosity of the cultured buttermilk had some effect also upon the dispersion of the granules. The higher the viscosity the better was the distribution of the granules at these higher temperatures. The granules should, however, be mixed at as low temperatures as possible, because the lower the temperature the greater the viscosity and, therefore, the better the distribution. The granules had a tendency to be in the upper half of the container at high temperatures owing to the decreased viscosity. The tendency of the granules to soften and to mat together was due to the comparatively low melting point of butter fat. It is quite probable, that after a longer period of time than two hours the matting and rising of the granules would become more intense, when the higher temperatures were used. Also, high temperatures of storing would enhance other defects which would render the buttermilk unsatisfactory.

Cream improved the flavor of granuled buttermilk, especially when the cultured buttermilk used had a tendency toward an off flavor, or was high in acid. The flavor of the cream was such that it seemed to overcome or mask the off flavor and the high acidity. When the cultured buttermilk was of good flavor, however, there appeared to be only a slight advantage in adding cream to the product.

Apparently, it was immaterial whether 20 or 40 per cent cream was used as both the creams gave similar results when equivalent amounts of fat were used. It was quite likely that cream testing within the range of 20 to 40 per cent butter fat could be used with equally as good results.

One to one and five tenths per cent cream appeared to be the correct amount to add to obtain the best results. Any amount over one and five tenths per cent gave the granuled buttermilk too creamy a flavor, which was not to the advantage of the desired product.

The above discussion is offered as a possible, partial explanation of some of the results obtained, after taking into consideration all the factors that were involved.

CONCLUSIONS

1. There is very little similarity in the chemical and physical properties of cultured and churn buttermilk as analyzed, except in the percentage of total solids.

2. The granule addition method of making granuled buttermilk is much superior to the churn method of making this product.

3. Viscosity of the cultured buttermilk used has an important bearing on the dispersion of the butter granules. Viscosities as low as 65.56 centipoises may be used, but for best results viscosities over 74.56 centipoises should be used.

4. Butter granules have no effect on the wheying off of granuled buttermilk.

5. The best results as to flavor and appearance of granuled buttermilk are obtained when from eight tenths to one per cent of granules are added.

6. Temperatures of cultured buttermilk as high as 85° F. may be used when mixing the granules and cultured buttermilk, but it is not advisable to use this high temperature. The granules should be mixed with the cultured buttermilk at as low a temperature as possible.

7. Forty per cent cream added to granuled buttermilk in amounts from one to one and five tenths per cent by volume improves the flavor, especially if the cultured buttermilk used has a tendency toward an off flavor. There is but a slight advantage in adding cream when the cultured buttermilk is of good quality and flavor.

8. Twenty per cent cream can be used to improve the flavor instead of 40 per cent cream with similar results, providing equivalent amounts of fat are added.

9. The size of the butter granules has some effect on the dispersion properties. Granules the size of small wheat kernels are to be recommended for giving the best flavor and appearance without affecting the dispersion.

Showing the effect of various degrees of viscosity on granule dispersion. The picture on the left indicates high viscosity and good dispersion; the center, lower viscosity and poorer dispersion, while the picture on the right shows the effect of very low viscosity.

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