A STUDY OF HOMOGENIZED MILK

SHOWING THE EFFECTS OF VARIOUS PROCESSING PROCEDURES ON FLAVOR, SEDIMENT CONTROL, AND BACTERIA COUNT

by

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INTRODUCTION

The practice of homogenizing milk for fluid consumption is a comparatively recent development in the dairy industry. Hollingsworth (25) stated that an unsuccessful attempt was made to market homogenized milk at Lacolle, Quebec in 1910. It was first marketed successfully in Ottawa in 1927. Esmond (18) stated that despite its recent introduction, homogenized milk is now being sold by nearly every concern of importance in Canada. Sales of homogenized milk in the United States have increased during the last few years (27, 28, 39), and increased milk consumption has been reported wherever the product is sold (18, 26, 29, 40).

Homogenized milk as defined in the 1939 Standard Milk Ordinance and Code (33) is "milk which has been treated in such a manner that after a storage period of 48 hours tests of the 100 cc portion decanted from the top of a quart bottle of milk will not show a difference in fat content over tests of the remainder of the bottle after thorough mixing exceeding 5 per cent of the total fat content."

The purpose of this study was to obtain data showing the effect of certain processing procedures on the flavor, sediment control, and bacteria count of homogenized milk.

REVIEW OF LITERATURE

Homogenization Practices

Equipment and methods. Several types of machines are available for the homogenization of liquids. In the conventional type, pressure, maintained by the action of pistons or a rotary pump, forces the liquid through one or two adjustable valves. In this treatment all particles are reduced in size and the liquid is given a homogeneous character. Chambers (5) described a new method of obtaining the same effect using sound waves as the causative agent. In this method an electrically driven sonic oscillator is used. Milk subjected to this treatment is said to be comparable to milk homogenized under pressure. A new type of homogenizer was recently announced in which milk is forced through preforations in the outer edge of a swiftly revolving bowl. As the milk passes through these preforations it comes in contact with metal shoulders. This contact at great velocity tends to shear the fat globules and reduce their size.

Single vs. double homogenization. Single homogenization consists of forcing milk through a machine which has one adjustable valve. Double homogenization consists of forcing milk through a machine which has two adjustable valves, thus subjecting it to double treatment. The effect produced by double or two stage homogenization can be obtained, according to Doan and Minster (16), by passing the milk through a single stage machine two times. These authors stated that two stage homogenization results in a product having less viscosity, greater casein stability, lower curd tension, and higher dispersion of fat than does single stage homogenization.

Dahle and Jack (9) and Webb (48) found that there was much more clumping of fat globules when milk was homogenized only once. A second pressure treatment tended to disperse the clumps.

Effect of Homogenization

Fat separation. The prevention of fat separation during storage is accomplished by reducing the size of the fat globules. Tracey (39) found that milk must be subjected to 2000 pounds pressure per square inch, at a temperature of not less than 115°F., to prevent fat separation for 24 hours, and that 3000 pounds pressure may be required if the milk is stored several days. Trout, Halloran, and Gould (44) showed that 1500 pounds pressure was sufficient to prevent creaming to any appreciable extent in homogenized raw milk which had been pre-heated to 90°F., and in milk pasteurized at 145°F. for 30 minutes before homogenization. Creaming was eliminated when 2500 pounds pressure was used.

Webb (48) found that a second homogenization, at the same pressure as the first, retarded the rise of fat in milk more than the single treatment did.

The degree of fat separation is in direct proportion to the size of fat globules. The average size of fat globules in milk pasteurized at 145°F. for 30 minutes was reported by Trout, Halloran, and Gould (44) to be as follows: Unhomogenized--3.89 microns, homogenized at 500 pounds--2.50 microns, homogenized at 1500 pounds--1.91 microns, and homogenized at 2500 pounds--1.38 microns. Tracy (39) obtained data which agreed with these very closely.

Whitaker and Hilker (49) found that a temperature of 100°F. or more was required for milk homogenized at 3000 pounds pressure in order to obtain fat globules averaging less than three microns in diameter. Their work showed that the milk must be at least 90°F. when homogenized at 3000 pounds pressure to prevent the formation of a cream layer.

Tracy (40) stated that in properly homogenized milk the fat remained as a stable emulsion even after the milk had been frozen and was allowed to thaw.

Cream separation was not affected by the clumping of fat globules according to Doan (11).

Flavor. Babcock (1) allowed 470 consumers to compare the flavor of homogenized milk with that of untreated milk. Of this group 36.6 per cent favored the homogenized milk, 37.9 per cent favored the untreated milk, and 25.5 per cent had no preference.

Charles (6) stated that homogenization cannot be applied to raw milk because of the development of rancidity. This flavor is due to enzymatic action on the fat complex. Ramsey and Tracy (34) showed that as the rancid flavor developed the titratable acidity increased. This reaction suggested hydrolysis of the fat; the reaction was the same in both homogenized and unhomogenized milk, but occurred at a much faster rate in the former.

Trout, Halloran, and Gould (44) showed that pasteurization before or immediately after homogenization prevented the development of rancidity. Doan (14) proved that a flash heating to 147°F., holding at 134°F. for 15 minutes, or at 132°F. for 30 minutes was sufficient to prevent the development of rancidity in homogenized milk for 24 hours.

An experiment performed by Babcock (1) showed that raw milk homogenized at 86 to 104°F. was most likely to become rancid. This author stated that the pressure of homogenization had no effect on the development of rancidity.

Dorner and Widmer (17) published findings to the effect that rancidity increased with an increase in the pressure of homogenization. Their work also showed that the acidity of the milk used had an effect on the development of this flavor. All samples to which N/4 NaOH was added became rancid rapidly after being homogenized, but those to which 2N HCl was added did not become rancid, or just slightly so. These workers further showed that addition of as little as 1 per cent of raw milk to pasteurized homogenized milk caused the development of rancidity in 30 hours.

Tracy, Ramsey, and Ruehe (41) showed that homogenization was effective in the prevention of oxidized flavors even in milk to which copper had been added. They attributed this effect to a change in the physical nature of the milk which made the flavor less readily detectable by organoleptic methods. They further showed that homogenization had little or no effect on the oxidation-reduction potential of the milk treated.

Ross (35) showed that a pressure of 1500 pounds per square inch at a temperature of 115° F. was sufficient to prevent the development of an oxidised flavor in all samples of milk to which copper had been added. He concluded that homogenization, by finely dividing the fat globules and coating them with a film, is effective in protecting the globules from enzymatic attack.

Thurston, Brown, and Dustman (38) found that pressures as great as 2000 pounds were not always effective in preventing oxidized flavors in milk which contained 2.6 parts per million of $CuSO_4$. They attributed this effect, in part at least, to a realignment of lecithin adsorbed on the fat globules.

Tracy (40) stated that when homogenized milk is exposed to the sun's rays it develops a more pronounced burnt flavor in 10 minutes than will unhomogenized milk. He also warned that cooked flavors may result from the increase in temperature that occurs when milk is subjected to the pressure of homogenization. Trout, Halloran, and Gould (44) gave the following temperature changes due to homogenization pressure: no pressure -0.6°F., 500 pounds -0.8°F., 1500 pounds +0.5°F., 2500 pounds +6.1°F., and 3500 pounds +8.1°F.

Chemical properties. Data obtained by Trout, Halloran, and Gould (44) showed that homogenization of raw milk resulted in an increase in titratable acidity. When such milk was stored there was further increase in acidity. Homogenization of pasteurized milk did not increase its titratable acidity, nor did storage affect this property. Pre-heating to 145°F. prior to homogenization was effective in preventing any change in acidity. Pasteurization after homogenization did not alter the acidity established by that treatment, but did prevent its further development.

Gould and Trout (20) subjected homogenized milk to various chemical tests and found no change in Reichert-Meissel number, Polenski number, or refractive index of the fat. The acidity of the fat was increased materially, and there was further increase during 24 hours of storage. These changes were not noted in unhomogenized milk.

__Physical properties__. Trout, Halloran, and Gould (44), using a Westphal balance, found no change of importance in the specific gravity of milk subjected to homogenization. Babcock (1) found that only rarely was enough air incorporated in the homogenization process to affect the lactometer reading. Determinations made with a Westphal balance showed that homogenization did decrease the specific gravity slightly. The decrease was directly proportional to the pressure of homogenization. The author stated that this effect was not permanent, as aging of samples lessened the decrease of specific gravity.

Tracy (40) observed that homogenization brought about a color change in milk that was apparent to the eye. Using a Keuffel and Esser color analyzer, he found that the homogenized milk had a less intense color than did the untreated milk. Higher pressures of homogenization caused still further decreases in color intensity. Trout, Halloran, and Gould (44) observed that milk subjected to homogenization had a slightly lighter but more uniform color. These workers found that homogenized milk always imparted a lighter color to coffee than did an equal amount of untreated milk.

Washburn (45) stated that skim milk had less viscosity after being homogenized than before, but that after 24 hours of storage the homogenized sample regained its original viscosity. Trout, Halloran, and Gould (44) found that the viscosity of raw milk increased with an increase in the pressure of homogenization, but that the viscosity of pasteurized milk decreased with an increase in pressure. Doan and Minster (16) found that the increase in viscosity due to homogenization was directly proportional to the fat content of the milk. They stated that homogenization increased the tendency toward fat clumping in milk of a high fat content, thereby increasing its viscosity materially.

Trout, Halloran, and Gould (44) obtained data on twelve lots of milk indicating that homogenization of raw milk tends to decrease the surface tension, but that on pasteurized milk the surface tension was slightly increased. Doan and Minster (16) obtained essentially the same results on raw milk.

Work done by Trout, Halloran, and Gould (44) indicated that homogenization of milk decreased the stability of the protein toward alcohol, irrespective of whether the milk was raw or pasteurized. The effect was less marked in the pasteurized samples. As the pressure of homogenization increased, the destabilizing effect became more pronounced. Doan and Minster (16) obtained the same results, and found that the destabilizing effect was much greater on samples containing a higher per cent of fat. These same workers (15) also determined that re-homogenization increased protein stability. Webb (48) found that a pressure of 500 pounds for the second homogenization gave the maximum increase of stability over that of the singly treated samples.

Doan (12), by lowering the pH of milk with lactic acid, demonstrated that the decrease in pH which accompanies homogenization accounted for only a small fraction of the decrease in protein stability. The addition of alkaline salts caused a stabilization of protein in both homogenized and unhomogenized samples. The addition of acid or calcium salts had an opposite effect. This worker concluded that the calcium concentration may be the important factor.

All the results reported show that homogenization decreased the curd tension of milk. Tracy (39) presented data to show that on pasteurized milk the curd tension was inversely proportional to the pressure of homogenization. He also showed that there was little difference in the curd tension of homogenized pasteurized milk when the temperature of homogenization was between 75 and 140°F. Whitaker and Hilker (49) found that the curd tension of raw milk was inversely proportional to the temperature of homogenization. A study of pasteurization temperatures by Tracy (40) showed that the higher the temperature of pasteurization, the lower the curd tension. When temperatures as high as 185°F. were used, homogenization gave no further decrease in curd tension.

Theophilus, Hansen, and Spencer (37) and Caulfield and Martin (4) showed that double homogenization did not give a lower curd tension than did a single treatment. These authors also showed that a much greater per cent of reduction was obtained on milk originally having a high curd tension than on that with a low curd tension.

Nutritive value. Doan (13) stated that homogenized milk forms softer curds in digestion. Washburn (46) stated that milk treated in such a manner as to give small curd particles was more generally suitable for infant feeding. He listed homogenization as one of the two best ways of accomplishing this result. Hill (23, 24) gave a number of examples in which infants benefited by the change from natural to soft curd milk. Tracy (40) published findings to the effect that soft curd milk had no decided nutritional values for infant feeding.

Washburn and Jones (47) conducted a feeding trial with homogenized milk using small pigs. They found a greater utilization of fat from homogenized milk than from untreated milk. Their results showed that in all cases there was a greater gain per calorie intake on the homogenized than on the unhomogenized milk.

Bacteria count. Brueckner (3) stated that usually homogenized milk had a higher bacteria count than did the same milk unhomogenized. He attributed this increase to two factors: contamination from the homogenizer, and breaking up of clumps and chains of organisms. He advocated the use of a presumptive test for Escherichia coli to show whether or not contamination had occurred.

Tracy (39, 40) and Corbett (8) reported that plants which sold both homogenized and pasteurized milk were found to have higher counts on the homogenized product. Tracy (39) gave a detailed procedure, including eight steps, for the sterilization of a homogenizer. Corbett (8) found that it was possible to prevent the homogenizer from being a source of contamination by soaking the packing in a saturated salt or chlorine solution when the machine was not in use.

Hollingsworth (25) found the fact that homogenized milk could be pasteurized at a higher temperature than unhomogenized milk, since there was no cream line, of significant importance. He asserted that it was possible to manufacture low count homogenized milk. An example was given in which one distributor of both homogenized and pasteurized milk had a lower count on the former product ten months of the year.

Frequently it is necessary to clarify milk after it has been homogenized. The effect of clarification on the bacteria count of milk has been noted by Hammer (21), Hammer and Hansen (22), Lucas, Cooledge, Goodwin, and Werdon (31), and McInerney (32). They agreed that clarification generally resulted in higher bacteria counts. They also found that this treatment reduced the leucocyte or epithelial cell count of the milk materially. McInerney (32) reported that clarified milk showed less increase of bacteria during storage than did unclarified milk.

<u>Sedimentation</u>. Charles and Sommer (7), and Trout, Halloran, and Gould (44) concluded that the sediment formed in homogenized milk might be either dirt or milk solids or both of these. Babcock (1) reported that the sediment

consisted mainly of leucocytes and epithelial cells. Tracy (39) showed that the amount of sediment in homogenized milk was directly proportional to the leucocyte count of that milk.

Charles and Sommer (7) stated that sediment forming materials were found in all milk. Babcock (1) found that in unhomogenized milk these materials carried to the top by the rising fat, but that in homogenized milk they settled to the bottom of the bottle. Charles and Sommer (7) found that creaming was an effective factor in reducing sedimentation.

Trout and Halloran (43) and Charles and Sommer (7) found that the sediment score of raw milk had no relationship to the amount of sediment in that milk after it had been homogenized.

Tracy (40) proved that the temperature of homogenization had no correlation with the amount of sediment formed. Trout and Halloran (42) and Babcock (1) showed that the pressure of homogenization had no influence on the amount of sediment formed.

Several workers (1, 7, 40, 44) found that clarification after homogenization was the only sure method of preventing sediment formation. Their work showed that filtration had little or no effect on sedimentation, and that clarification of milk before it was homogenized reduced the amount of sediment but did not prevent its formation.

Testing. Babcock (1) reported that fat tests made by the Babcock method on milk before and after homogenization gave a reading 0.05 to 0.15 per cent low on the homogenized samples. Trout, Halloran, and Gould (44) advocated the use of acid having a specific gravity of 1.815 to 1.82 for Babcock tests on homogenized samples. Tracy (39) advised the addition of acid in small quantities to the test bottles, with thorough mixing between each addition, and the use of about 1.5 ml. less than the normal amount of acid in order to obtain clear fat columns on Babcock tests of homogenized milk.

Consumer preference. Tracy (39) made a survey of homogenized milk consumers to determine what qualities made the product so popular. Some of those listed were: 1. looks and tastes richer, 2. no cream adheres to cap or bottle, 3. no mixing is necessary, 4. better for cereals, 5. there is no temptation to remove cream, and 6. children and adults prefer it. Some of the disadvantages listed were: 1. lack of cream for other uses, and 2. sours more quickly.

Sale of other dairy products. Several surveys have been reported indicating that an increase in the sale of cream usually occurs when homogenized milk is introduced (27, 30).

Esmond (18) stated that homogenized milk should prove valuable as a carrier for vitamin D. One Illinois dairy (28) reported that the sale of homogenized vitamin D milk had doubled in thirteen months, and that it was selling five times the volume of plain milk.

Price. Layson (30) reported that fifteen or sixteen manufacturers contacted were selling homogenized milk at the same price as the unhomogenized. An article in the Milk Dealer (2) stated that in general the price of homogenized milk was the same or slightly higher than that of pasteurized milk.

Governmental Regulation

A survey was conducted by the Milk Dealer (36) in 1936 to determine the legal status of homogenized milk in the various states. Fifteen states had no regulation pertaining to the product. Eighteen states reported that the sale of homogenized milk would be permitted if it was properly labeled. Four states prohibit the sale of homogenized milk.

Those municipalities which have adopted the standard milk ordinance recommended by the United States Public Health Service (33) make homogenized milk meet the same requirements as pasteurized milk.

Doan (10) reported that microscopic examination was all that was necessary to ascertain whether or not a sample of milk has been homogenized.

Farrall and Hanson (19) have developed a technique for evaluating the efficiency of homogenization by the use of photomicrography methods.

Although considerable work has been done on the problems connected with this product, some are unsolved. The question of sediment control is still unsettled. The fact that some commercial plants are not bothered with this defect indicates that some of the causes are unknown. The question of improving the flavor of the product is an important one. The problem of bacteria count of the homogenized milk is of vital importance from the quality standpoint.

The purpose of this research was to obtain additional information on these problems in order that they might be controlled in the commercial plant.

EXPERIMENTAL PROCEDURE

Equipment

College dairy. This research problem was conducted in the college dairy of Kansas State College. The equipment and facilities of the creamery were available for use whenever needed.

Homogenizer. The homogenizer used was a 1930 model, single stage machine manufactured by the Creamery Package Manufacturing Company. It had a rated capacity of 100 gallons per hour. A small overhead supply tank was attached to the inlet in order to facilitate the handling of small quantities of milk. The pressure guage of this machine was checked to insure accuracy.

Clarifier. A DeLaval centrifugal clarifier, model 110, was available for use. This machine had a capacity of 2000 pounds per hour; power was furnished by a one horsepower electric motor. A small raised supply tank was used for this machine.

Filter. Samples which were not subjected to clarification were filtered through a small farm strainer. This strainer was constructed of tinned iron and had a preforated metal bottom. A cotton filter disc was placed over the bottom piece, then a preforated metal disc was placed over the cotton disc. A second preforated metal disc was placed several inches above the first to act as a baffle plate. Cotton filter discs purchased from Johnson and Johnson Company were used.

Pasteurization. A Kontrol-Flo cooler, model A O, manufactured by the Superior Metal Products Company, was used as a high temperature continuous flow pasteurizer. Hot water, the temperature of which was controlled by mixing steam and water, was circulated through the heating plate. Milk was heated as it flowed across this plate in a thin film. The time of pasteurization was controlled by the rate of flow of the milk through the device. This equipment was also used as a pre-heater in one series.

Pasteurization by the holding method was accomplished by placing the container of milk in a tank of hot water. The temperature of the water was sufficiently high to produce the desired temperature in the milk, usually three to five degrees higher than the pasteurization temperature desired. The temperature of the heating water was maintained with steam.

Pasteurization was accomplished in two types of containers.

Samples which were pasteurized before homogenization were heated in well tinned three or five gallon ice cream cans. Samples which were pasteurized after homogenization were heated in wide mouth 128 ounce glass jugs.

Samples which were not pasteurized before homogenization were pre-heated to near the pasteurization temperature before they were subjected to the pressure treatment. Pre-heating was accomplished in ten gallon milk cans.

In all pasteurization treatments agitation was supplied by hand.

A standard floating dairy thermometer, of the spirit-mercury type, which had been checked for accuracy, was used for temperature control.

Methods

Records. Accurate records were made of all characteristics of the milk, processing procedures, and information obtained by examinations.

General. Two sources of milk were utilized. In series IV samples were obtained from cows known to give milk having specific flavor defects. For the other series, samples were chosen at random from the patrons milk received at the college creamery.

The milk was received in the morning. It was strained to remove the foreign material and tested for quality. It was then subjected to the heat treatment and the homogenization treatment. After processing, the samples were collected, cooled, and examined.

Samples. After the milk had been processed, samples were collected in ordinary glass milk bottles. Quart samples were taken for sedimentation studies and half-pint samples were taken for flavor and bacteriological examination. The milk was placed in the bottles while still hot, the bottles were capped with a plain, flat, plug type cap, and then they were placed in ice water until cool. After the temperature had been lowered to 50°F. or lower, the samples were placed in an insulated cooler and held until examined.

Storage. The samples used for flavor and sediment studies were held for three days. During this time the temperature of the cooler fluctuated between 35 and 45°F.

Examination. The first examination of the milk was made as soon as it was strained. The acidity was determined with N/20 NaOH using phenolphthalein as the indicator. The score for flavor and odor was taken at this time. The sediment from a pint of the milk was obtained on a standard lintine disc using a vacuum type sediment tester. This disc was compared with standard discs and given a numerical score of zero to ten according to the amount of foreign material it contained, with ten being a perfect score.

Organoleptic examinations to determine the flavor of the processed samples were made immediately after they were cooled, and after a three day period of storage. The identity of the samples was unknown to the persons scoring them. Samples were warmed to approximately 70°F., and two to four experienced judges scored them individually.

The quart samples were observed after a three day period of storage and the amount of sediment present was noted. No exact measure of the amount of sediment was available, so a visual estimation of the quantity had to suffice. The bottles were scored on a zero to five basis, with zero indicating no sediment and five indicating a very heavy deposit. In case of a questionable sample, a half point was added to the lower possible score.

In series II bacteria counts were made to determine the relative efficiency of various pasteurization treatments. Counts were made on the samples as soon as they were cooled. The samples were plated on the new standard media as outlined by the American Public Health Association in the Seventh Edition of Standard Methods for the Examination of Dairy Products.

Processing Procedures

Series I. This series was conducted to determine what effect, if any, a variation in the pressure of homogenization had on the flavor and the amount of sediment in the processed milk. The pressures studied were 1500, 2500, and 3500 pounds per square inch. For this series a ten gallon lot of milk was divided into two parts. Part A was pasteurized at 143°F. for 30 minutes and was then homogenized. In order to obtain samples from the three pressures being studied, the machine was first adjusted to 1500 pounds pressure and the sample was collected, then the machine was adjusted to 2500 pounds pressure and a second sample was taken. By following this technique samples were collected from each of the pressure treatments. Part B of the original lot of milk was pre-heated to 140°F. and homogenized as was part A.

Samples were taken in the same manner as part A, but were subsequently pasteurized at 143°F. for 30 minutes. Samples were cooled, examined, and stored for later examination as previously outlined.

Series II. This series was conducted to determine the effect that various pasteurization treatments might have on the flavor, sedimentation tendencies, and bacteria count of homogenized milk. The pasteurization treatments studied were: 1. holding at 143°F. for 30 minutes, 2. holding at 150°F. for 30 minutes, and 3. a continuous flow pasteurization at 160°F., in which the milk was held at that temperature for approximately one minute. A lot of milk was divided into two parts. Part A was subdivided into three quantities, one each of which was subjected to one of the pasteurization treatments. After being pasteurized the samples were homogenized at 2500 pounds pressure, care being taken to rinse thoroughly the homogenizer between each quantity of milk put through it. Part B of the original lot of milk was pre-heated to 140°F., homogenized at 2500 pounds pressure, and three separate quantities were collected, one each of which was subjected to one of the pasteurization treatments. Samples were collected, cooled, examined, and stored for later examination as previously outlined.

Series III. In series III the effect of various methods of removing foreign material from milk subjected to homogenization was studied. A lot of milk was divided into five parts. Part A was filtered through a cotton disc filter while at a temperature of 60 to 65°F. It was then pre-heated to 140°F. and homogenized at 2500 pounds pressure. A quantity of the homogenized milk was collected in a wide mouth glass jug and was pasteurized at 143°F. for 30 minutes. Part B was warmed to 100 to 105°F., filtered, pre-heated, homogenized, and pasteurized as part A. Part C was pre-heated to 140°F. and homogenized. The homogenized milk was then filtered through a cotton disc filter, and subsequently pasteurized as parts A and B. Part D of the lot of milk was treated just as was part B above except that in the place of filtration, the milk was subjected to centrifugal clarification. Part E of the lot of milk was treated just as part C above except that centrifugal clarification replaced filtration in the sequence of processes. Samples for examination were collected, cooled, and stored as outlined.

Series IV. This series of trials was made in order to determine the effect of homogenization on milk having various flavor defects. The milk used in this series was collected at the evening milking from cows giving milk having particular off flavors. The milk was strained, then cooled and held till the following morning at which time it was processed. All lots of milk were first pasteurized at 143 to 145°F. for 30 minutes. They were then homogenized at 2500 pounds pressure per square inch. Half-pint samples were taken in triplicate of the raw milk, the milk after being pasteurized, and after it was homogenized. The samples were cooled in ice water and were held for flavor examination. The first sample was scored immediately after processed. A second sample was scored after one day of storage, and the third of the triplicate samples was scored after three days of storage. Flavor examinations were the only ones made on the series of trials.

Series V. The results of the first four series indicated that the acidity of the milk had a direct bearing on the formation of sediment. The fifth series was added to obtain additional data on this factor. Two methods of study were used in this series. For the first three trials a lot of milk was divided into three parts. Part A was held at -45°F. and parts B and C were held at about 70°F.

The milk was held until the acidity of parts B and C was .17 to .21 per cent as determined by titration with N/20 NaOH. At that time the acidity of part C was neutralized back to approximately .15 per cent by the addition of Wyandotte C. A. S., a cream neutralizing agent manufactured by the J. B. Ford Company of Wyandotte, Michigan. Each part of the milk was then pasteurized at 143°F. for 30 minutes, and was homogenized at 2500 pounds pressure. The last two trials differed from those above in that part A was pasteurized and homogenized soon after being received, while parts B and C were held as before. Samples of the pasteurized homogenized milk were collected, cooled, and stored for examination as outlined before.

EXPERIMENTAL RESULTS

Flavor Studies

Homogenization pressure. The effect of different homogenization pressures on the flavor of milk was studied in this series of trials. Three pressures were used. Data were obtained on the effect of these pressures on milk which was pasteurized before homogenization, and on milk which was pasteurized after homogenization. The flavor scores of samples subjected to pressures of 1500, 2500, and 3500 pounds per square inch are given in Table 1.

Six trials were made using the three pressures listed. The untreated milk used in these trials had a mean flavor score of 19.8 when fresh and 19.3 after three days of storage. The homogenized samples had a mean flavor score of 21.2 when fresh, irrespective of the pressure used. The samples homogenized at 1500 and 2500 pounds pressure had a mean score of 21 after three days of storage; those homogenized at 3500 pounds had a mean score of 20.9. This small difference is not significant.

Pasteurization treatments. This phase of the problem consisted of a series of trials in which six different pasteurization treatments were used. The effect of these various treatments on the flavor of the samples of homogenized milk was noted. The data obtained relating to the flavor score of samples subjected to the various treatments are presented in Table 2.

Table 1. Flavor score of fresh and stored samples of milk homogenized at different pressures

Trial No.	Fresh samples: Raw	Fresh samples: 1500*	Fresh samples: 2500*	Fresh samples: 3500*	After three days storage: Raw	After three days storage: 1500*	After three days storage: 2500*	After three days storage: 3500*
	Milk pasteurized before homogenized							
14	22.5	22.5	22.5	22.5	22.0	22.0	22.0	22.0
15	16.5	20.0	20.0	20.0	17.0	19.5	19.5	19.5
16	20.0	22.0	22.0	22.0	20.0	21.3	21.0	21.3
17	19.8	21.5	21.5	21.5	17.0	20.5	20.5	20.5
18	18.8	20.3	20.3	20.3	18.5	21.0	20.5	20.0
19	21.3	21.8	21.8	22.0	21.0	21.5	21.5	21.3
	Milk pasteurized after homogenized							
14a		22.5	22.5	22.5		22.0	22.0	22.0
15a		19.0	19.0	19.0		19.5	19.5	19.5
16a		21.0	21.0	21.0		21.0	21.3	21.7
17a		21.3	21.3	21.3		20.3	20.3	20.3
18a		20.0	20.0	20.0		21.8	21.5	21.0
19a		22.3	22.5	22.3		22.0	22.0	22.0
Mean	19.8	21.2	21.2	21.2	19.3	21.0	21.0	20.9

*Pressure in pounds per square inch.

Table 2. Flavor score of samples of homogenized milk subjected to various pasteurization treatments

Trial No.	Fresh raw	After three days of storage						
		Raw	Past. before homo.			Past. after homo.		
			143° F. 30 min.	150° F. 30 min.	160° F. 1 min.	143° F. 30 min.	150° F. 30 min.	160° F. 1 min.
27	21.0	22.5	22.0	22.0	21.5	22.0	22.0	21.5
28	22.0	22.0	22.0	22.5	22.5	22.0	22.0	22.0
29	22.0	21.0	22.0	22.0	22.0	22.5	22.5	22.5
30	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
31	21.5	19.0	19.0	22.0	22.0	22.0	22.0	22.0
32	21.0	22.0	22.5	22.5	22.5	23.0	23.0	23.0
33	23.0	12.0	21.0	21.0	21.0	21.0	21.0	22.0
34	23.0	22.5	22.5	22.5	22.5	22.5	22.5	22.5
35	17.5	18.5	20.5	20.5	20.5	20.5	20.5	20.5
Mean	21.4	20.8	21.5	21.9	21.8	21.9	21.9	22.0

Table 3. Flavor score of three day old samples of homogenized milk subjected to different methods of sediment removal

Trial No.	Fresh raw	Three day old samples					
		Raw	Filtered at 60-65° F.	Filtered at 100-5° F.	Filtered after homo.	Clarified at 100-5° F.	Clarified after homo.
23	22.0	21.0	22.0	22.0	22.5	23.0	23.0
24	21.0	20.5	20.5	21.0	20.5	20.0	19.5
25	22.0	22.5	22.0	22.0	23.0	22.5	23.0
26	20.0	20.0	21.0	21.0	21.0	21.0	21.0
Mean	21.3	21.0	21.4	21.5	21.8	21.6	21.6

The nine samples of milk used in these trials had a mean flavor score of 21.4 when raw. The same samples, after three days of storage had a score of 20.2, or a decline of 1.2 points. Those samples which were pasteurized and homogenized did not show such a decline. The mean flavor scores for the treated samples were as follows: pasteurized before homogenized at 143°F. for 30 minutes, 21.5; at 150°F. for 30 minutes, 21.9; and at 160°F. for one minute, 21.8; pasteurized after homogenized at 143°F. for 30 minutes, 21.9; at 150°F. for 30 minutes, 21.9; and at 160°F. for one minute, 22.0.

Removal of foreign material. In this series of trials different methods of removing the foreign material contained in milk were studied. The effect of these different treatments on the flavor of homogenized milk was observed. Data obtained are presented in Table 3.

The four samples of milk used in these trials showed but little decline in score during storage. The mean score of the fresh raw samples was 21.3 and of the same samples after storage was 21.0. The mean score of the stored homogenized samples was as follows: filtered at 60-65°F., 21.4; filtered at 100-105°F., 21.5; filtered after homogenized, 21.8; clarified before homogenized, 21.6; and clarified after homogenized, 21.6.

<u>Initial</u> <u>quality</u> <u>of</u> <u>milk</u>. In this phase of the experiment the relationship of the flavor score of the homogenized samples to the initial flavor of the milk was studied. The data obtained showing the relationship between the initial flavor and the flavor of fresh and stored samples of homogenized milk are given in Table 4.

Homogenization increased the flavor score over that of the raw milk in four cases by an average of 0.9 points, and lowered it in nine cases by an average of 0.6 points. On the same samples after three days of storage, the flavor score was higher on the homogenized milk in ten cases by an average of 1.6 points, lower in two cases by an average of 0.9 points, and unchanged in one case.

Table 4. Flavor score of fresh and stored samples of milk before and after pasteurization and homogenization

No.	Fresh samples			After 3 days storage		
	Raw	Past.	Homo.	Raw	Past.	Homo.
1	20.6	21.3	20.9	17.0	18.0	21.4
2	19.0	20.5	20.9	16.5	14.5	18.5
3	23.0	22.8	22.4	20.5	21.4	21.8
4	21.1	21.5	21.0	19.5	18.5	21.0
5	16.6	16.3	17.4	15.5	15.5	17.3
6	20.6	20.6	21.1	20.0	20.0	20.2
7	19.9	19.8	19.3	18.5	18.5	18.7
8	19.5	20.0	18.1	19.2	17.3	20.8
9	22.5	22.3	21.9	22.7	22.3	22.0
10	17.5	17.9	17.3	17.3	17.0	17.7
11	22.6	22.0	21.6	22.2	22.0	22.2
12	20.4	21.0	20.0	20.0	20.7	19.0
13	19.8	19.5	19.3	17.0	16.0	20.8
Mean	20.3	20.4	20.1	18.9	18.6	20.1

The mean score of these thirteen samples shows that on the fresh samples pasteurization alone improved the flavor score by 0.1 points and homogenization lowered the flavor score by 0.2 points. When these samples were scored after three days of storage it was found that the flavor score had decreased 1.8 points on the pasteurized samples, and 1.4 points on the raw samples; but the flavor score of the homogenized samples had remained the same. It should be pointed out that ten of these thirteen lots of milk became oxidized, rancid, or metallic during storage.

When the lots of milk were segregated into flavor groups, it was found that homogenization affected various flavors in different ways. In seven trials the untreated samples became oxidized or rancid when held in storage; Those flavors were not evident in the homogenized samples. The oxidized flavors occurred in the pasteurized samples, the raw samples became rancid. The mean flavor scores for those seven lots of milk are given in Table 5.

Table 5. Mean flavor scores of seven lots of pasteurized and homogenized milk which tended to become oxidized or rancid during storage

Milk	Fresh samples	Stored samples
Raw	19.9	17.9
Pasteurized	20.3	17.3
Homogenized	20.0	20.2

This study showed that homogenization did prevent the development of rancid or oxidized flavors in milk. The flavor scores of the raw samples averaged two points lower after storage than when fresh. The pasteurized samples showed a three point lower mean flavor score after storage than when fresh. The mean flavor score of the homogenized samples was two-tenths of a point higher after storage.

In three of the trials a metallic flavor developed in the homogenized samples. The mean flavor scores for those lots of milk are given in Table 6.

Table 6. Mean flavor scores of three lots of pasteurized and homogenized milk which developed metallic flavors in homogenized samples during storage

	Fresh samples	Stored samples
Raw	20.3	19.5
Pasteurized	20.5	19.7
Homogenized	20.1	19.3

This study showed that pasteurization increased the mean flavor score two-tenths of a point and that homogenization decreased it two-tenths of a point on the samples scores while fresh. All samples showed a decline in flavor score of eight-tenths of a point during storage. Although the homogenized samples were found to possess a metallic flavor it was so slight as to cause very little difference in the flavor score.

The milk used in eight trials was judged to have a cowy or feedy flavor; the same samples were called cooked after being homogenized. The mean flavor score of those samples is given in Table 7.

Table 7. Mean flavor scores of eight lots of homogenized milk which showed cowy or feedy flavors in raw samples and cooked flavors in homogenized samples

Milk	Fresh samples	Stored samples
Raw	20.6	20.1
Homogenized	21.5	21.2

The flavor scores on these lots of milk showed that homogenization improved the flavor of the fresh samples from 20.6 to 21.5. The raw samples showed a decline of five-tenths of a point in flavor score during storage and the homogenized samples showed a decline of three-tenths of a point. Nearly all of the samples that were designated as "cowy" or "feedy" before homogenized were termed "cooked" after homogenization. The homogenized samples were rarely called "cooked" unless the raw samples were found to have slight off flavors such as "cowy" or "feedy". This indicates that the "cooked" flavor is one which results from heating milk having those off flavors. The "cooked" flavor was judged to be less objectionable than that present in the raw milk.

Sedimentation Studies

<u>Homogenization pressure</u>. Three homogenization pressures were studied in order to determine what effect variations might have on the amount of sediment formed. An estimation of the amount of sediment found in the bottles of milk subjected to the different homogenization pressures is given in Table 8.

These data indicate that the pressure of homogenization has little effect on the amount of sediment formed. There was a tendency for the higher pressure to give more sediment on some samples. This tendency was much more evident when the milk was pasteurized before being homogenized.

Table 8. Amount of sediment in three day old samples of milk homogenized at different pressures

Key: 0--no sediment, 1--very slight, 2--slight, 3--medium

Trial No.	1500 lbs.	2500 lbs.	3500 lbs.
Milk pasteurized before homogenized			
14	0	1	0.5
15	2	1	3
16	2	2.5	3
17	2.5	3	3
18	3.5	3.5	3
19	0	0.5	1
Milk pasteurized after homogenized			
14a	1	1	1
15a	0.5	0.5	1
16a	1	1.5	2
17a	1	0.5	0.5
18a	2	2	2.5
19a	0	**	0
Mean	1.3	1.4	1.7

** Some small dirt particles visible.

Pasteurization treatments. Six pasteurization treatments were studied. The effect of the various treatments on the amount of sediment formed in homogenized milk was noted. The data obtained from this study are presented in Table 9.

The data obtained from this study show that the pasteurization treatment which the milk receives is not an important factor in the amount of sediment formed.

Table 9. Amount of sediment in three day old samples of homogenized milk subjected to various pasteurization treatments

Key: 0--no sediment, 1--very slight, 2--slight, 3--medium

Trial No.	Raw	Past. before homo. 143°F.: 30 min.	150°F.: 30 min.	160°F.: 1 min.	Past. after homo. 143°F.: 30 min.	150°F.: 30 min.	160°F.: 1 min.
27	**	**	1	0	2	2	1
28	0	1	1	1	1	1	1
29	0	3	3	3	2.5	3	3
30	**	3	3	3	1.5	2	1.5
31	**	0.5	0.5	0.5	0.5	1	1
32	**	0.5	0	0	**	0	0
33	0	2	2	2	2	2	2
34	0	1	1	1	1	1	1
35	**	1	0.5	1	1	0.5	1
Mean		1.5	1.3	1.3	1.3	1.4	1.3

** Some small dirt particles visible

Removal of foreign material. Five treatments for the removal of foreign material were studied. The effectiveness of these treatments in the prevention of sediment formation in samples of homogenized milk was noted. The data obtained by this study are given in Table 10.

The data indicate that clarification after homogenization was the only certain method of preventing sediment formation. Clarification prior to homogenization materially reduced the amount of sediment but did not prevent its formation. Filtration, either before or after homogenization, had little or no effect on the amount of sediment.

Table 10. Amount of sediment in three day old samples of homogenized milk subjected to different methods of sediment removal

Key: 0--no sediment, 1--very slight, 2--slight, 3--medium, 4--heavy, 5--very heavy

Trial No.	Raw	Filtered at 60-65°F.	Filtered at 100-5°F.	Filtered after homo.	Clarified at 100-5°F.	Clarified after homo.
22	0	**	**	0	**	0
23	**	4	5	5	**	0
24	**	3	3	3	**	0
25	**	1.5	1	2	1	0
26	**	2	0.5	3	**	0
Mean		2	2	2.6	0.2	0

** Some small dirt particles visible

<u>Initial</u> <u>quality</u> <u>of</u> <u>the</u> <u>milk</u>. The factors studied in this phase of the problem were acidity and sediment score of the milk.

Twenty-six trials were made in which the effect of these two factors on the amount of sediment formed in homogenized milk was noted. Figure 1 shows the correlation between the factor obtained by combining acidity and sediment score into one variable, and the amount of sediment found in the homogenized milk. This scatter diagram was plotted using the values calculated in Table 11.

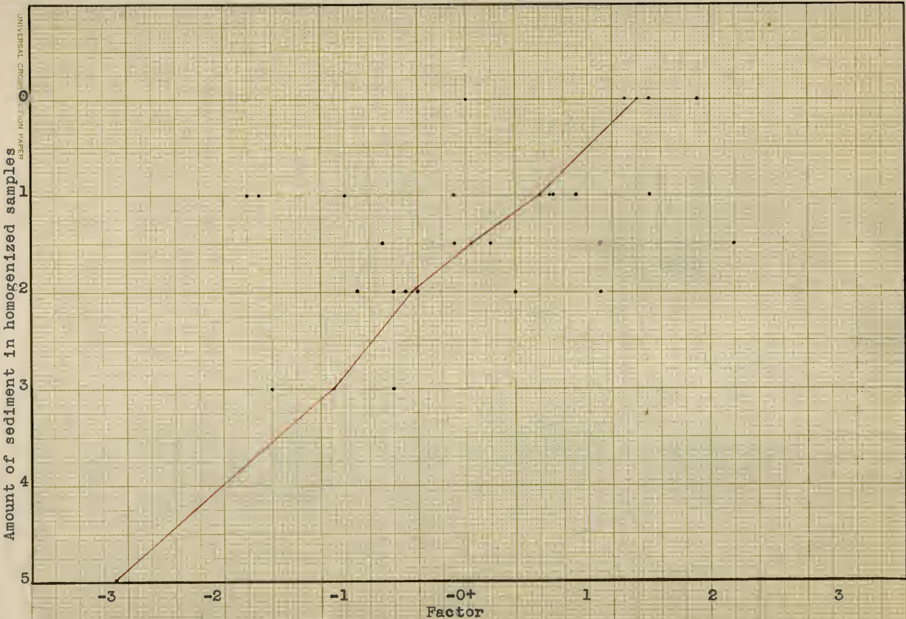

Fig. 1. Correlation between factor and amount of sediment; data taken from Table 11.

Table 11. Acidity and sediment score of raw samples of milk, standard scores obtained for those characteristics, factors calculated from standard scores, and amount of sediment in homogenized samples

Trial No.	Titratable acidity[1]	Standard score	Sediment score	Standard score	Factor	Amount of sediment[2]
14	.15	2.2	7.5	-1.0	0.6	1
15	.16	0.9	9.5	0.8	0.9	1
16	.14	3.6	9.5	0.8	2.2	1.5
17	.175	-1.1	9.7	1.0	-0.1	1
18	.18	-1.7	9.5	0.8	-0.5	2
19	.145	2.9	9.5	0.8	1.9	0
20	.15	2.2	9.0	0.4	1.3	0
22	.17	-0.4	9.0	0.4	0.0	0
23	.185	-2.4	5.0	-3.2	-2.9	5
24	.18	-1.7	7.0	-1.4	-1.6	3
25	.16	0.9	8.0	-0.5	0.2	1.5
26	.175	-1.1	8.5	-0.1	-0.6	2
27	.16	0.9	8.5	-0.1	0.4	2
28	.16	0.9	9.0	0.4	0.7	1
29	.175	-1.1	8.5	-0.1	-0.6	3
30	.18	-1.7	9.0	0.4	-0.7	1.5
31	.185	-2.4	9.0	0.4	-1.0	1
32	.15	2.2	9.5	0.8	1.5	0
33	.175	-1.1	9.0	0.4	-0.4	2
34	.15	2.2	9.5	0.8	1.5	1
35	.195	-3.7	9.0	0.4	-1.7	1
36	.15	2.2	8.5	-0.1	1.1	2
37	.19	-3.0	8.0	-0.5	-1.8	1
38	.16	0.9	9.0	0.4	0.7	1
39	.165	0.3	8.0	-0.5	-0.1	1.5
40	.17	-0.4	7.0	-1.4	-0.9	2
N--26	M--.167	SD--.76	M--8.6	SD--.89		

[1]Calculated as per cent lactic acid.

[2]Estimated amount in homogenized samples: 0--no sediment, 1--very slight, 2--slight, 3--medium, 4--heavy, 5--very heavy.

A statistical analysis of the data was necessary to show the correlation between the acidity and sediment score of the raw milk, and the amount of sediment in the homogenized samples. The first step was to obtain a standard score for the titratable acidity. To do this it was first necessary to calculate the mean of the values. The standard deviation from this mean was next calculated. The standard score was calculated by dividing the deviation of each value from the mean by the standard deviation. Those values lower than the mean were given positive scores because they represented the better quality of product. The standard scores of the sediment scores were obtained in the same manner. In this case those values higher than the mean were given positive scores because they represented the better quality of product. The factors used for correlation with the amount of sediment in the homogenized samples were obtained by computing the average of the standard scores for acidity and sediment. The standard scores were added algebraically and the sum obtained was divided by two. By using this technique the positive factors obtained represented good quality milk, and the negative factors represented poor quality milk. The correlation represented in Figure

1 shows that the good quality milk is much less likely to have sediment than was the poor quality milk. The trend line in Figure 1 was drawn through the median value at each sediment scale level.

It was impractical to obtain a coefficient of correlation because of the small number of trials and because of the small number of dividions in the scale used for estimating the quantity of sediment in the homogenized milk.

Another series of trials was run to obtain additional information on the effect of titratable acidity on the amount of sediment formed. In this series the effect of artificially lowering the acidity by the addition of an alkali was studied. The data obtained in this study are presented in Table 12.

These results indicate that an increase in acidity does not give an increase in the amount of sediment formed. It should be noted that the acidity was high in the fresh samples. In order to allow this fact to stand, and also allow the correlation found in Figure 1 to have significance, it must be concluded that the factors which are operative are the initial acidity of the milk and the amount of foreign material it contains.

These data show that an artificial reduction of acidity to, or near, the initial acidity is effective as a preventive of sediment formation unless the amount of foreign material contained in the milk is excessive. The factor obtained by the method used in Table 11 shows the same correlation with the amount of sediment formed as shown in Figure 1.

Bacteria Counts

Pasteurization procedures. Various pasteurization procedures were studied in the second series of trials. Bacteria counts were run on some of the samples in this series in order to learn the efficiency of the various pasteurization treatments. The bacteria counts of the raw, pasteurized, and homogenized samples are presented in Table 13. In this table the counts of the homogenized samples are compared with those of samples that were pasteurized at 143°F. for 30 minutes.

Table 12. Sediment score of raw milk and acidity of each portion of milk subjected to homogenization and the estimated quantity of sediment in homogenized samples after three days of storage

Key: 0--no sediment, 1--very slight, 2--slight, 3--medium

Trial No.	Fresh samples: Sediment score	Fresh samples: Acidity	Amount sediment in homo.	Samples aged to develop acidity: Acidity	Samples aged to develop acidity: Amount sediment	Neutralizer: Acidity	Neutralizer: Amt. sed.
36	8.5	.15	2	.17	2	.15	0.5
37	8.0	.19	1	.205	1	.17	1
38	9.0	.16	1	.205	1	.155	0
39	8.0	.165	1.5	.18	1	.145	0
40	7.0	.17	2	.175	2	.15	2

Table 13. Number of bacteria per ml. of fresh samples of raw, pasteurized, and homogenized milk subjected to various pasteurization treatments

Trial No.	Raw samples	Past.[1] not homo.	Past. before homo.: 143°F. 30 min.	Past. before homo.: 150°F. 30 min.	Past. before homo.: 160°F. 1 min.	Past. after homo.: 143°F. 30 min.	Past. after homo.: 150°F. 30 min.	Past. after homo.: 160°F. 1 min.
30	72,500	4,600	6,450	1,800	3,500	6,800	4,860	2,950
32	7,800	750	2,900	1,400	5,750	2,215	2,400	3,000
33	1,500,000	24,500	89,500	35,000	31,000	50,500	46,000	45,000
34	71,000	6,750	7,000	6,800	3,550	3,200	3,100	2,800
35	1,020,000	700	5,800	3,000	4,000	2,050	1,250	2,400
Mean[2]	144,000	3,313	9,255	4,477	6,158	5,316	4,507	4,346

[1]Pasteurized at 143°F. for 30 minutes

[2]Logarithmic mean

The logarithmic mean count of the five samples indicate that homogenized milk will generally have a higher count than the same milk unhomogenized. The mean counts obtained were as follows: raw, 144,000; pasteurized only, 3,313; pasteurized before homogenized, at 143°F. for 30 minutes, 9,255; at 150°F. for 30 minutes, 4,477; at 160°F. for one minute, 6,158; and pasteurized after homogenized, at 143°F. for 30 minutes, 5,316; at 150°F. for 30 minutes, 4,607; at 160°F. for one minute, 4,846.

DISCUSSION

Flavor Studies

Other workers (17, 35, 38) have found that different pressures of homogenization may affect specific off flavors in diverse ways. It was found that rancidity increased with increases in pressure; oxidized flavors were prevented when pressures of 1500 pounds per square inch or more were used.

This research was concerned with the effect of various pressures on good quality milk, that is, milk which did not tend to develop any serious off flavors. The results showed that there was very little difference in the flavor of the homogenized milk irrespective of the pressure used. A pressure of 2500 pounds apparently was the optimum.

No report was found of studies made by other workers in which various pasteurization treatments were used. The results obtained in this study indicate that better flavor results from the use of higher pasteurization temperatures than are normally used on milk. It was also evident that pasteurization after homogenization was advantageous.

The part of this study showing the effect on flavor of various methods of removing foreign material apparently was original; no reports of work of a like nature have been found. The data obtained on this phase of the problem indicate that no one method results in a better flavored product than another method.

Considerable work has been reported (1, 18, 26, 29, 40) showing the consumer reaction to homogenized milk. Most of it stated that at least one reason given for the preference for homogenized milk was its better flavor. This study was made to find out what comparison in flavor actually exists. The data obtained in this study indicated that there was only a small difference in the flavor of the fresh samples of raw and homogenized milk. Apparently homogenization did not change the flavor any appreciable extent. The homogenized samples practically always scored higher in flavor than did unhomogenized samples after a storage period.

The results obtained in this study agreed with other reports in the effectiveness of homogenization as a preventive of oxidized flavors. No other work was reported showing the effect of homogenization on such flavors as "cowy" and "feedy". This study showed an improvement in the flavor of the milk possessing those flavors.

Sedimentation Studies

Other workers (1, 42) have previously shown that the pressure of homogenization has little or no effect on the amount of sediment formed. The findings of this study were in agreement with those facts.

The findings of this research were to the effect that pasteurization treatment was not an active factor in the amount of sediment formed. No previous study of a like nature has been reported.

Previous studies (1, 7, 40, 44) have shown that centrifugal clarification after homogenization was the only sure method of preventing sedimentation in some milk. The results of this study agree with those findings.

Several workers (7, 43) have indicated that the sediment score of the raw milk was not an accurate guide for the selection of milk for homogenization. No attempt had been made to find the effect of the acidity of the milk on the amount of sediment formed in the homogenized samples. The data obtained in this research indicates a direct correlation between the acidity and sediment score of the raw milk and the amount of sediment formed. These findings offer one solution to a problem that has heretofore been troublesome. In the light of previous knowledge one was unable to give a logical reason why some commercial plants had no trouble with the formation of sediment, and other plants, operating under like conditions, found large quantities of sediment. If the correlation found in this research holds true under commercial conditions, the reason for this discrepancy between plants becomes apparent. The cause for this difference probably lies in the quality of milk being used for homogenization. It would seem that the easiest method of preventing sediment formation would be to improve the quality of milk being homogenized.

This study showed that artificial reduction of acidity to that of the fresh milk was effective in diminishing the quantity of sediment formed in homogenized milk unless an excessive amount of foreign material was present. This part of the research was conducted to find out what effect acidity had, and is not recommended as a commercial practice. While no exact study was made, it was observed that the flavor score of the neutralized samples was considerably lower than that of the other samples.

Bacteria Counts

No previous study has been reported showing the effect of various pasteurization treatments on the bacteria count of homogenized milk. Several workers (2, 7, 39) have reported increased counts in homogenized milk over that of pasteurized milk. One report (24) stated that the bacteria count of homogenized milk could be as low as that on pasteurized milk because of the possibility of using higher temperatures on the former. Pasteurization temperatures of 150 to 160°F. were found to be more efficient than was the regular temperature of 143°F. The results of this study indicate that even increased pasteurization efficiency will not overcome the increase in count due to homogenization. It was found that a lower count usually resulted when pasteurization followed homogenization than when these processes were accomplished in the reverse order.

CONCLUSIONS

1. A homogenization pressure of 1500 to 3500 pounds per square inch is satisfactory. The optimum pressure is probably about 2500 pounds.

2. Pasteurization of homogenized milk can be accomplished satisfactorily at a higher temperature than that used for unhomogenized milk. Pasteurization should follow homogenization.

3. The method used for the removal of foreign material from milk is unimportant as far as flavor is concerned. Centrifugal clarification is the only sure method of preventing sediment formation in some samples of homogenized milk.

4. The quality of milk used for homogenization is the most important factor involved. It must have a high flavor score if the flavor of the finished product is to be good. It must be handled so as to be low in acidity and free of excessive amounts of foreign material if the bottles of homogenized milk are to be free of sediment.

5. The procedure recommended for the production of homogenized milk is as follows:

a. Select the best quality of milk available. It should be fresh, low in acidity, and free of foreign material.

b. Filter as usual for removal of any foreign material.

c. Pre-heat to 140°F. in a continuous flow pre-heater.

d. Homogenize at 2500 pounds pressure per square inch.*

e. Pasteurize by holding at 150°F. for 30 minutes, or at 160°F. for one minute, using the method most readily adaptable.

f. Cool, bottle, and deliver as usual.

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*If sediment forms in the bottles it would be necessary to clarify at this point.

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