AN ABSTRACT OF THE THESIS OF

Bayard Walter Hillway FOR THE M.S. IN Dairy Mfg.
(name) (degree) (major)

Date Thesis presented May 5, 1939

Title The Vacreation of Cream for Butter

Abstract Approved: [redacted]

The preparation of cream for butter-making by Vacreation consists essentially of ultra-flash pasteurization by instant direct contact of the cream particles with steam of adjusted temperature in low vacuum; the removal of extraneous objectionable flavors by steam distillation in intermediate vacuum; and cooling and concentration of the cream in high vacuum.

An investigation into the problem of feed, weed, and other objectionable flavors in the butter, and the application of vacreation for their removal from cream, along with the pasteurization and general conditioning of the cream, was undertaken.

Butter was made over a six months' period from the regular supply of cream to the Oregon State College Dairy Products Laboratory, and at times from cream sent in from various parts of the state. "Split" churnings were made of all cream; one batch being vacreated, the other, pasteurized by the regular holding method, was run as a check.

Examination was made of (1) the fresh butter, (2) after holding the butter one month at 40° to 50°F., (3) and after holding four months at 0° to 10°F. Gradings favored the fresh vacreated butter 3.4 to 1, with 73.7 per cent of the vacreated and 38 per cent of the non-vacreated samples scoring 92 or

better.

Butter held one month at 40° to 50°F. showed little difference between the vacreated or non-vacreated butter.

Cold storage butter held four months gave results favoring the vacreated butter almost exclusively (90 per cent).

Special samples embodying cream possessing such intense flavors as "kale", "weed", "onion", and "scale weed" or "French weed" showed efficient removal of these flavors when the cream was treated by vacreation. Flavors such as "old cream", "oxidized", or "metallic", which were symbolic of chemical changes in the cream, and probably due to conditions in transit from various parts of the state, were not entirely removed, however.

Pasteurization by vacreation far surpassed pasteurization by the holding method. Counts ranged from 100 to 6,500 bacteria per cc. and averaged 1,363 bacteria per cc. for the vacreated cream. Similarly, counts ranged from 800 to 50,000 bacteria per cc. and averaged 19,413 bacteria per cc. for the holding method.

Average efficiencies of the destruction of bacteria were 99.996 per cent and 99.801 per cent respectively for pasteurization by vacreation and by the holding method. Yeasts and molds were destroyed with 100 per cent efficiency by both methods.

Alterations in churning technique showed lower neutralization and lower churning temperatures possible with vacreated cream; a smoother, firmer, and more uniform bodied butter resulted.

Although average pH values indicated a slightly higher active acidity in the non-vacreated butter in both the fresh and in the storage butter, no apparent difference in the trend of these values characterized the vacreated or the non-vacreated butter. The average drop in value during storage for one month at 40°to 50°F. was 0.11 for the vacreated butter, and 0.10 for the non-vacreated. No check was obtainable on butter held four months in cold storage.

THE VACREATION OF CREAM FOR BUTTER

by

BAYARD WALTER HILLWAY

A THESIS

submitted to the

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1939

APPROVED:

[redacted]

Professor of Dairy Manufacturing

[redacted]

Head of Department of Animal Industries

[redacted]

Chairman of School Graduate Committee

[redacted]

Chairman of State College Graduate Council

An Appreciation --

To Mr. F. S. Board, of Auckland, New Zealand who so generously aided me with his advice and kind assistance throughout much of this research.

Table of Contents

THE VACREATION OF CREAM FOR BUTTER

Introduction

The impulse to eat more or to eat less of the butter on the table is controlled almost wholly by the senses of taste and smell. The flavor of butter is, therefore, the most important factor in quality. The body and texture are of considerable less importance but, nevertheless, do contribute to the appetizing and appealing quality of butter.

By"flavor," is understood a combination of taste and aroma. There are only four primary tastes, namely: sweet, acid, bitter, and salt. These are determined chiefly by the tongue and taste organs located in the mouth. Very infinitesimal substances are responsible for the aroma. These are determined by the organs of smell. Some of these can be observed by smelling the substances before they are placed in the mouth; while others are observed while the food is being masticated. (23) If butter has a fine flavor and aroma, people will eat it in increasing quantities so long as the price does not reach a prohibitive point. This was clearly demonstrated in New South Wales, Australia,(3) where, within a comparatively short time after the introduction of a rigid state grading system which prohibited the sale of second grade butter on the local market, the per capita consumption almost doubled.

The vital part of butter manufacture within the factory lies in processing the cream; purifying it bacterially and chemically, correcting excess acidity, cooling, and ripening prior to churning. The butter-maker who is handling cream that is highly charged with objectionable feed flavors has, therefore, a truly difficult problem. It was, primarily, to overcome this problem that the present study of the vacreation of cream was undertaken.

Invented in 1925, in New Zealand, a country which manufactures 380,000,000 pounds of butter annually, (1936-37) under strict governmental supervision, this process was designed to treat cream in a manner that would more effectively pasteurize and remove feed flavors from it without harming its delicate natural character.

Although this process has, since its advent in 1925, developed so rapidly as to become standard practice in New Zealand, Australia, and South Africa, the Oregon Agricultural Experiment Station is the first in the United States to investigate its possibilities under American conditions.

History of Pasteurization (1)

About the year 1695, in Delft, Holland, Anton van Leeuwenhoek, the discoverer of microorganic life, found that blistering coffee would kill some of the bacteria in his mouth. This was, perhaps, the first stage in the development of our modern technique of pasteurization; although it has undoubtedly been practiced since the earliest times when the milk of mares and other animals was boiled in earthen vessels.

It was a century and a half later, in August, 1857, that Pasteur reported to the Scientific Society, at Lille, France, that heating, by destroying certain germs, would postpone the souring of milk.

Leeuwenhoek discovered that heat would kill microorganisms. Pasteur discovered further that some types of microorganisms spoiled wine, beer, and milk.

Many types of bacteria in milk are entirely harmless, while others are extremely dangerous; but early pasteurization was not primarily concerned with public health. It was used in an effort to conserve milk so that it would be salable longer--"not only for days," as one investigator wrote, "but for weeks and even months." The health standpoint was also recognized, however, especially where infant feeding was concerned.

The term "pasteurization, " as applied to milk, came into use during the period 1880-1890 to describe the process of heating milk in bottles for infants to destroy germs. Dr. Abraham Jacobi had begun to preach the doctrine of boiled milk for babies in the 1870's; but it was not until 1887, when Soxhlet conclusively proved that the feeding of sterile milk to babies reduced the number of diarrhea cases materially, that medical men became pasteurization conscious.

The general wide acceptance of pasteurized milk today, is probably due to the influence of the charity of Nathan Straus, who through the efforts of Dr. A. Caille, Dr. Jacobi, and Dr. R. G. Freeman, was interested in the many benefits of pasteurization and its possibilities in the home.

Beginning in 1893, he made pasteurized milk available to infants in New York City, when 34,000 bottles were distributed. Today, the use of pasteurized milk is almost universal.

Progress in the development of pasteurization equipment (1)

Progress in pasteurization equipment has come about chiefly by concentrating upon the elimination of the defects in existing systems of equipment which advancing research in bacteriology and in pasteurization methods have revealed.

Beginning with Albert Fesca's (Berlin, Germany) first "continuous working apparatus" in 1881, no satisfactory commercial apparatus was built until 1906 when Joseph Willmann invented the first continuous holding system. Refinements of this machine now dominate the field of commercial pasteurization; although various other methods are used and approved.

Pasteurization as applied to the butter industry (22)

Although pasteurization as we now know it was first applied to the butter industry in Denmark in 1888, perhaps its first application took place when, in the olden days, the milk freshly drawn from the cows was placed on the open fire or stood in boilers of water to scald. During this scalding process the steam from the milk percolated up through the cream layer, thus killing the bacteria in a most effective manner without injuring the delicate cream flavors. Excessive feed flavors, such as occur in milk at certain seasons of the year, were modified by the cleansing action of the steam.

As applied to butter-making, pasteurization may be defined as the process of heating milk or cream to a temperature sufficiently high and for a time sufficiently long to insure the destruction of germs of milk borne diseases and the great majority of non-pathogenic germ life and other ferments, and of cooling quickly to the ripening or churning temperature.

Because the destruction of microorganisms is a progressive reaction (19), the time of heating and its relation to the temperature of pasteurization must be considered together.

Hunziker (9) recommended the following pasteurization temperatures and holding periods for the pasteurization of cream for butter making:

145°F. for 30 minutes

160°F. for 15 minutes

170°F. for 5 minutes

180°F. or over, momentary exposure.

Research at Oregon State College with regard to the influence of different pasteurizing temperatures in killing bacteria, yeasts and molds, found that temperatures of 150°F., 155°F., and 158°F. held for 30 minutes gave average efficiencies, in the destruction of bacteria, of 99.94 per cent, 99.96 per cent, and 99.94 per cent respectively for the above temperatures. Yeasts and molds were destroyed with 100 per cent efficiency in all cases.

Macy (5) found that the holding method was slightly superior to the flash method for the destruction of molds. The efficiencies of mold destruction being from 99.6 to 100 per cent for the holding process and 93.2 per cent for the flash.

Today, despite our modern equipment, feed flavors are still confronting the dairy industry. Despite the removal of certain of these flavors by modern pasteurization, most methods, because the cream is in contact with high-temperature steam heated metal surfaces until the pasteurization temperature is reached, tend to fuse these flavors into the fat globules rather than to expel them. (22)

Early attempts toward the removal of feed flavors (9)

Up to the present, the principles involved in methods and attempts made to remove these objectionable flavors and odors from cream may be grouped under the following classes:

1. heating the cream under reduced pressure
2. treating the heated cream with air
3. treating the heated cream with air under reduced pressure.
4. replacing the air in the cream by carbon dioxide
5. treating the cream with chemicals
6. separating the butter fat and purifying the butter oil by washing, centrifuging, filtering, and drying

In many cases, these basic principles have demonstrated their soundness when applied to this end; but years of practical experience have established the fact that the results obtained with most equipment designed for the application of these principles do not justify the expense of its installation and operation.

Recent trends in the removal of feed flavors

The most recent trend of scientific investigation in the field of obnoxious flavor removal is toward the utilization of pasteurization by the direct addition of steam to the cream.

Of numerous machines developed along this principle are the following:

The Grindrod Impact Sterilizer (8)

The Grindrod Impact Sterilizer consists of a modified "hot-well" which is connected directly with a condensing pan, such as is commonly used in the manufacture of condensed and evaporated milk. The hot-well is constructed with a tight sealable cover so that high pressure steam can be maintained throughout the entire system of the apparatus.

The pressure is maintained in the hot-well compartment by the introduction of high-pressure steam which is introduced into the bottom of the hot-well through a nozzle which breaks the steam into fine jets.

The process of sterilization is as follows: Milk is added to the hot-well and, after closing the container, a vacuum of 24 to 26 inches is drawn upon the entire apparatus with a suction pump. When this degree of vacuum is reached, steam under a pressure of 30 to 40 pounds per square inch is introduced through the nozzle into the milk in the hot-well, and allowed to heat the milk until the latter reaches the desired temperature. After the proper period of sterilization, the milk is drawn rapidly over into the condensing pan where such excess moisture as is condensed into the milk during the steaming process is removed. Sterilization will take place within a period of two or three minutes, depending upon the type of organism in the milk, while the condensing time in the pan depends upon the time the milk has been kept in contact with the high pressure steam.

Results of research:--

"The efficiency of this process in sterilizing milk has been studied using milk cultures of pure strains of organisms of known heat resistance as well as uninnoculated milk which had been allowed to develop a heat-resistant flora.

"A temperature of 230° Fahrenheit held for one to two minutes has been found to eliminate all non-thermophilic organisms from milk. The thermophilic heat-resistant types were materially reduced at this temperature, but 240°F. for three to five minutes was required to free milk from this type of organism.

"The Grindrod process of sterilizing milk may be capable of being adapted to the process of condensing and drying milk. Its use in the market milk field may be confined to semi-tropical and tropical conditions where sterility is essential even at the cost of affecting the cream line or other physical properties of the milk.

"This method of sterilizing has certain disadvantages, viz., it destroys the cream line, gives a slight 'boiled' flavor, and at the high temperatures used there is a slight precipitation of the albumin. On the other hand, its advantages include the possibility of completely sterilizing milk both of the thermophilic and non-thermophilic types, the rapidity of the process, and the removal, in certain cases, of dissolved odors and flavors."

The Jensen Super-Deodorizer (10)

Hot pasteurized cream is pumped at a uniform rate to a receiving tank equipped with a self-actuating float type cream feed valve. Operation of the feed valve permits the cream to leave the supply tank, from which it is automatically drawn through a cream line having the discharge end provided with a double nozzle from which the cream is released directly into a vacuum expansion pan. The cream, released from atmospheric pressure, expands and produces a separation of the groups and masses of fat. When the cream has reached this expanded condition, dry steam is introduced into it through a sanitary cream jet.

The cream, now discharged into a vacuum chamber proper, travels at high velocity in a thin stream within the main chamber of the machine. Here, it is claimed, the volatile substances are continually removed, and the previously mixed steam is thoroughly released to the condenser.

Claims-- (by manufacturer)

"Undesirable odors such as onion, garlic, kerosene, gasoline, feed flavors, and barn and cow flavors are completely removed."

Rogers' High Temperature Cream Pasteurizer and Vacuum Cooler (18)

Several years ago the C. E. Rogers Company introduced a cream pasteurizer employing temperatures as high as 300° F. Their most recent unit embraces this pasteurizer with the addition of positive two-stage coolers, embodying the use of a complete vacuum condensing unit.

The operation is as follows:--

(1) Cream is forewarmed and the acid standardized by conventional means.

(2) The supply pump forces the cream into the pasteurizing tube where dry steam is injected, instantly heating the cream to the desired temperature which may range from 220° to 300° F.

(3) The cream enters the first vacuum chamber through a specially designed diffusion head. The sudden expansion from pressure to vacuum through this head causes the cream to enter the vacuum chamber in a mist-like form. Evaporation in this chamber immediately cools the cream to 180° to 190° Fahrenheit.

(4) The cream is continuously removed from the first vacuum chamber to a vacuum pan through a sanitary pipe.

The higher vacuum maintained in the vacuum pan causes the cream to flow from one to the other. At this point the cream is re-exposed to the influence of a much higher vacuum in much the same manner as in the first vacuum chamber. Evaporation in this pan immediately cools the cream to approximately 140°F.

(5) The cream is continuously pumped from the vacuum pan to the cooler or vats.

Claims:-- (by manufacturer)

(1) "Perfect pasteurization."

(2) "Regardless of intensity, this machine will positively eliminate such off flavors as onion, garlic, potato, ensilage, cabbage, beet tops, turnips, etc. This holds true whether the offending flavor is the result of feeding conditions or exposure of the cream."

(3) "Being completely taken out these off flavors do not come back after the butter is stored."

H. C. Horneman Process for Pasteurizing and Deodorizing Liquids (7)

Operation:--

(1) Cream is forewarmed to 90° to 100° Fahrenheit and neutralized by conventional means. Sour cream is treated, preferably at 0.3 per cent and calculated as lactic acid.

(2) The cream is then quickly heated to a temperature

of 150° to 165°F. in a continous "flash pasteurizer."

(3) The cream is then transferred to a vacuum chamber through a distributor head. En route to this chamber, steam under 50 to 100 pounds pressure is introduced into the cream resulting in a pasteurizing temperature of 185°F.

Passage through the distributor head causes a fog of finely divided cream and water vapors and gases to be formed. The finely divided cream particles gradually coalesce and drop to the bottom of the chamber where they are withdrawn by the vacuum pump to the condenser system.

It is claimed by the inventor that "this invention is to provide a process whereby milk and cream with an imparted flavor or flavors, due to fermentation and/or feeds can be restored to its natural flavor."

<u>B. W. Hammer Process for Treating Lactic Fluids</u> (6)

<u>Operation</u>:--

(1) The cream, as received, is warmed to a point where it can be conveniently handled by the usual dairy equipment. Normally, this temperature will not exceed 100°F., preferably 90° to 100° F.

(2) After neutralization, the cream is quickly heated to a temperature of 150° to 165°F. in a conventional heating or preheating vat.

(3) The cream is pumped to an injector device where steam at 325° to 340° F. is injected to the cream resulting in a cream-steam-water mixture having a pasteurizing temperature of 200° to 250° F. or higher.

(4) The cream then passes through a distributor head into a vacuum chamber giving a vacuum of from 24 to 28 inches. The mixture is discharged from the distributor head in the form of a fog or mist from which the cream particles coalesce and the vapors are drawn off.

(5) Live steam under 80 pounds pressure is now bubbled through the collected cream. This is repeated three times more as the cream collecting in one compartment overflows into another until it is finally drawn off from the last compartment.

Removal of objectionable flavors is also claimed for this apparatus.

Scientific data on results obtainable from the machines mentioned above is at present lacking and, although a number are scattered throughout the nation, no one machine dominates the field.

<u>Vacreation in Foreign Countries</u> (22)

Abroad, in New Zealand, Australia, and South Africa, a process known as "Vacreation" has met with such wide success that it has become standard practice in those countries. In London, where butter from vacreated cream successfully competes with butter from the world's greatest dairy countries (e. g. Denmark) the following general opinion of vacreated butter is held:-- (22)

"They are less variable than other butters, clean in flavor, of good body and texture, and absolutely reliable in keeping quality. It is a butter that sells easily; a butter that is clean, sweet, reliable, and uniform. Vacreated butter is much more satisfactory than butters that vary in character."

<u>History of Vacreation</u> (13)

Evolved through experimental work by Mr. Lamont Murray and Mr. F. S. Board of Auckland, New Zealand, and based on Murray's findings that the boiling of milk tended to eliminate feed flavors from it, vacreation is a process involving the pasteurization, the removal of objectionable feed flavors from, and the partial cooling of cream under vacua.

The first experiments began in 1923, when Murray devised a method and apparatus for the continuous flow of cream while boiling in vacua. Two years of research and experiment resulted in the production of the first commercial machine. In 1930, as the result of wider knowledge gained through the commercial application of these first machines, an automatic unit of stainless steel was evolved which immediately gained popularity with the leading dairymen. Still not satisfied with this method, which employed two ordinary flash pasteurizers and a vacuum unit in tandem, and, since it has long been recognized that the ordinary methods of pasteurization have many drawbacks, the present, self-contained unit, which embraces pasteurization and the other phases in the one unit was designed.

Vacreation is defined (16) as consisting essentially of ultra-flash pasteurization by instant direct contact of the cream particles with steam of adjusted temperature in low vacuum; the removal of extraneous objectionable flavors by steam distillation in intermediate vacuum; and cooling and general conditioning of the cream in high vacuum.

Description of the "Vacreator" Vacuum Pasteurizer

The vacreator vacuum pasteurizer is made of stainless steel throughout. It consists of a receiving tank into which is fitted a float valve that works automatically admitting the cream flow to the pasteurizer but excluding air.

This receiving tank fits on top of the pasteurizing cylinder which tapers down to a rounded bend at the bottom. Fitting into the top of this pasteurizer is a spray pan containing 1/8 inch holes through which the cream showers down into the steam.

A thermometer is fitted into the rounded bend to indicate pasteurizing temperizing temperatures; while a ball valve, controlled by a lever, bowden wire, spring, and capstan wheel, is fitted at the bottom of the uptake pipe which leads into the steam distillation section. The capstan wheel governs the tension on the spring which controls by lever and wire, the ball of the "equilibrium valve." This in turn governs the vacuum and, automatically, the temperature in the pasteurizing section.

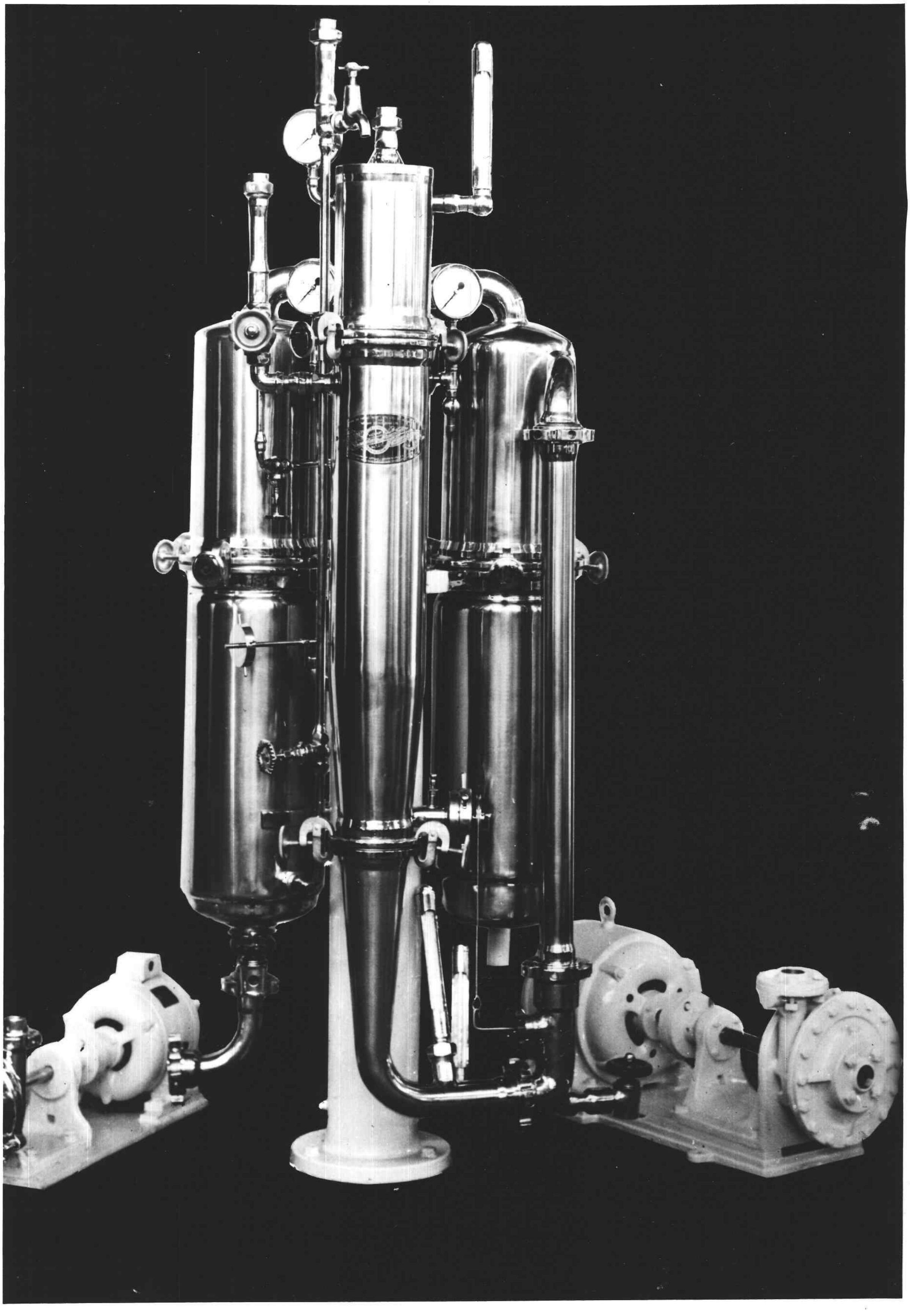
As the cream passes the equilibrium valve into the uptake pipe connected to the steam distillation section, it is subjected to the higher vacuum and, consequently, expands, resulting in a great increase in volume.

The steam distillation section has a removable dome that fits down on top of a rubber ring. From the center of the dome a 2 inch pipe extends down vertically into the chamber. This pipe extends over by a gooseneck to the ejector-condenser, its purpose being to convey the steam and gases liberated from the cream at the higher vacuum. This steam carries with it impurities from the cream to the condenser.

The cream leaves the cooling section by gravity at the bottom by a cream pipe coupled directly to a two-stage cream pump, whereby it is pumped away for further cooling.

The condenser is a cylindrical casing, the inside of which contains a fixed vertical nest of cones, the orfice of each being slightly larger than the preceeding one.

A water pressure pipe screws into the condenser headplate and a 9/32 inch nozzle directs the water through the cones. The water inlet pipe is fitted with a pressure gauge and a thermometer. Also, in the condenser is fitted a round and flat valve called a "Snifter" which is regulated by means of a wire and a sprocketed weight attached to a screwed fulcrum lever. The purpose of the snifter valve is to regulate the desired vacuum in the steam distillation section. A thermometer is also attached to the condenser water outlet.



The Vacreator Cycle (14)

(1) Cool water supplied under pressure to the Ejector-Condenser by the water pump, issues from a nozzle and shoots down through the multiple cones.

(2) The water jet ejects air and gases and condenses vapors coming over from the separating chambers, thus creating vacuum.

(3) The snifter valve, by regulating the admission of air to the condenser holds the vacuum at the point desired.

(4) Relatively high vacuum exists in the condenser, separating chambers, and uptake piple. The equilibrium valve curtails the vacuum to the pasteurizer.

(5) Live steam enters the pasteurizer, expands because of the vacuum, and instantly drops to the temperature prescribed by the vacuum.

(6) The pasteurizer is full of sterile diffused steam under low vacuum. The cold, raw cream containing the neutralizing agent is pumped steadily at any desired rate of flow into the float tank. The float valve automatically admits the cream flow to the pasteurizer, but excludes air.

(7) The spray pan receives the cream and converts it into a fine shower which falls by gravity without concussion through the rarefied steam in vacuum.

(8) The droplets instantly become saturated with heat from the steam, and boil at the precise pasteurizing temperature as prescribed.

(9) The boiling vaporous cream passes along to the equilibrium valve, the temperature being registered by the thermometer.

(10) The equilibrium valve automatically allows the passage of the high temperature boiling cream into the uptake pipe.

(11) Subjected now to higher vacuum, the cream expands and becomes more vaporous, volatile contaminations and some moisture being evaporated. The fat globules are cleansed and non-volatile impurities are washed away by the steam.

(12) Entering the separating chamber at velocity, the cream particles are automatically separated from the vapor and gases by centrifugal force.

(13) The vapors and gases carrying away the impurities pass up the vapor pipe and over to the condenser via the gooseneck.

(14) The used water conveys away the extracted heat, gases and impurities to waste; the intensity of the treatment being indicated by the temperature rise in the water as shown by angle thermometers.

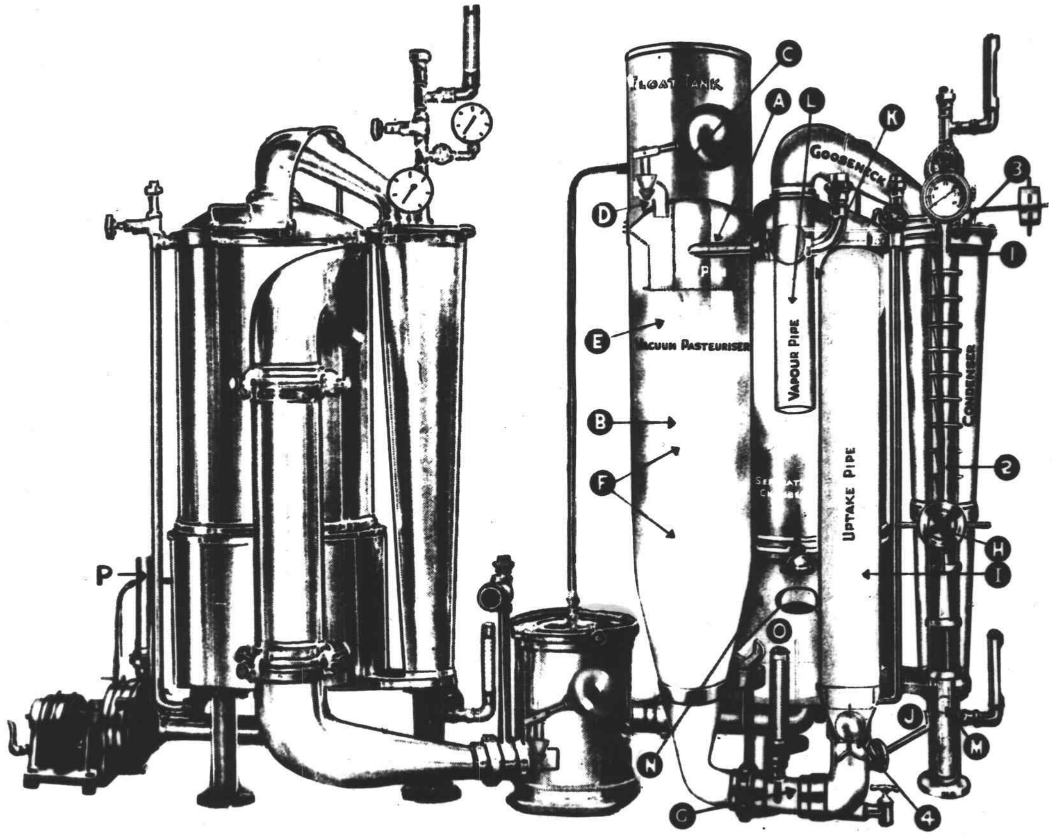
(15) The cream film spirals down the chamber walls and gives up much of its heat under vacuum. The water jacket

cools the cream slightly below the boiling temperature of the vacuum.

(16) The cream passes via a float valve to the secondary stage where the cycle is repeated under peak vacuum.

THE VACREATOR CYCLE ILLUSTRATED.

(REG. TRADE MARK)



Cool water supplied under pressure to the Ejector Condenser by the turbine pump, issues from a nozzle (1) and shoots down through the multiple cones.

The water jet (2) ejects air and gases and condenses vapours coming over from the separating chamber, thus creating vacuum.

The snifter valve (3), by regulating the admission of air to the condenser, holds the vacuum at the point desired—15in. to 18in.

Relatively high vacuum exists in the condenser, separating chamber and uptake pipe. The equilibrium valve (4) curtails the vacuum to the pasteuriser.

A.—Live steam enters here, expands because of the vacuum, and instantly drops to the temperature prescribed by the vacuum. (See Vacuum-Temperature Table.)

B.—The pasteuriser is full of sterile diffused steam under low vacuum.

C.—The cold raw cream containing the neutralising agent is pumped steadily at any desired rate of flow into the float tank.

D.—The float valve automatically admits the cream flow to the pasteuriser, but excludes air.

E.—The spray pan receives the cream and converts it into a fine shower which falls by gravity without concussion through the rarefied steam *in vacuo.*

F.—The droplets instantly become saturated with heat from the steam, and boil at the precise temperature of the steam as prescribed, *in vacuo.*

G.—The boiling vaporous cream passes along to the equilibrium valve, the temperature being registered by the thermometer.

H.—The equilibrium valve (4), controlled by spring tension adjustment, automatically allows the passage of the high temperature boiling cream into the uptake pipe.

I.—Subjected now to higher vacuum, the cream expands and becomes more vaporous, volatile contaminations and some moisture being evaporated.

J.—Additional steam is introduced by the infuser to effect intense cleansing of the cream particles. (Not fitted in the **Baby** unit.)

K.—Entering the cyclone separating chamber at velocity, the cream particles are automatically separated from the vapour and gas by centrifugal force.

L.—The vapours and gas carrying away the impurities pass up the vapour pipe and over to the condenser via the gooseneck.

M.—The used water conveys away the extracted heat, gases and impurities to waste; the intensity of treatment being indicated by the temperature rise in the water as shown by the angle thermometers.

N.—The cream film spirals down the chamber walls and gives up its excess heat under vacuum. The water jacket cools the cream slightly below the boiling temperature of the vacuum.

O.—The cream passes through a fine strainer to remove any casein or matter in suspension.

The cream next passes through a float-operated valve to the second separating chamber, repeating the cycle K to O **under peak vacuum,** which cools, concentrates and tones up the cream before it is pumped away at P to be chilled.

The Nature and Advantages of Principles Employed in Vacreation

The following explanations and theories are in the most part obtained from references and statements extended by Murray Deodorizers Ltd., manufacturers of the "Vacreation" Vacuum Pasteurizer.

The preparation of cream for butter-making by vacreation now consists essentially of (1) pasteurization, (2) the removal of various undesirable feed flavors, and (3) the general conditioning of the cream.

PASTEURIZATION

Pasteurization is accomplished by the instant heating of the cream through its direct contact with live, dry, saturated steam while in vacuum.

Preheating of the cream is avoided, except where it is necessary for the purpose of altering the consistency of the cream. By eliminating this, several distinct advantages are gained:- (15)

(1) Serum impurities are not fused into the fats prior to treatment.

(2) High acid cream does not foam so much and, therefore, a larger proportion of carbon-dioxide gas is evolved while under the vacuum. This assists in Vacreation.

(3) The chemical action of the neutralizer is

retarded, thus allowing opportunity for its even incorporation without risk of over-neutralizing any portions of the cream.

Division of the cream into droplets prior to pasteurization;

Upon entering the vacreator, the cream passes through a spray pan which divides it into droplets of such size (1/8 inch) as has been calculated to give the utmost efficiency to the pasteurization. This division of the cream prior to pasteurization greatly accelerates the heating of the cream upon its entry into the steam and, since the droplets fall as rain into the steam, rather than the steam passing into the cream, it also ensures even heating without convection currents, facilitates the liberation of carbon dioxide and other gases and vapors, and exposes the cream particles to the cleansing action of the steam.

Temperature control

The temperature of the steam is instantaneously and precisely controlled by its entry into the vacuum area. The principle involved here is that the temperature at which a liquid boils is dependent upon the pressure it is subjected to. When the air pressure on a liquid is reduced, the boiling point is lowered. Similarly, the temperature of the steam is lowered by its instant expansion in low vacuum, and standardized to that temperature at which it is desired to pasteurize before contacting the cream, thus avoiding overheating and interference with the true flavors of the cream constituents. Dry steam insures against the carrying over of impurities from the boiler.

Advantages of instant heating

This instant heating of the cream, which is now boiling under partial vacuum at the pasteurizing temperature, minimizes the risk of interference with the character and flavor of the true cream constituents. Because the cream so quickly reaches the boiling point at this temperature, there is no opportunity for impurities in the milk serum to fuse into the liquid fat globules, as occur during slower heating methods. Rather, there is a tendency toward the expulsion of these impurities.

Microorganisms present are unable to adapt themselves to the sudden temperature rise, and are so rendered less able to resist the heat. (15)

The brevity of this heat treatment, only two seconds, minimizes any interference with the vitamins and aids in the retention of the natural "bloom" of the cream. It also eliminates such risks as local overheating, oiling off of the fat, coagulation of the albumin, and contamination of steam odors which in the past have been the result of the direct introduction of steam into cream at atmospheric or increased pressures.(15)

Advantages of pasteurization in vacuum

Pasteurization in a vacuum insures that the adsorbed impurities will be driven off rather than driven into the cream during the heat treatment. The volatile fatty acids, vegetable oils and chemicals, air and gases which are normally adsorbed by the fat globules are extracted rather than absorbed by the fat, as they are during pasteurization involving longer heating periods. Vacuum, by reducing the air present during pasteurization, guards against oxidation of the fats and undue interference with the vitamins. Vacuum also insures an even heat saturation throughout the cream, since, at the peak temperature, the cream boils under low vacuum. It may aid in the destruction of the microorganisms present, since their inability to adjust themselves to the sudden reduction of pressure lowers their resistance to the high temperatures. (It should be noted here that both instant heating and a sudden reduction of pressure are thought to work together to lower the resistance of microorganisms to pasteurizing temperatures.)

REMOVAL OF OBJECTIONABLE FLAVORS

The removal of objectionable flavors is effected in two separate stages by washing with steam in vacuum, and is based on the following facts: (12)

Vegetable essential oils are of two main classes; volatile oils which are solvents and fatty oils which are not solvents but which are saponifiable.

Volatile oils combine with the butterfats by dissolving them and, therefore, when present in cream, contain fat in solution. Whether this oil-fat solution is in the form of free oil or whether it adheres to the surfaces of the fat globules is not known, but the latter is thought to be the case. The fatty oils also have a close affinity for the butterfat globules.

Only volatile oils are odorous, but both volatile and fatty oils have flavor. Odor may be removed by evaporation of the volatile constituents, but flavor principles must be dealt with by solution and entrainment, preferably in steam. The base of a fatty oil is not soluble in water or steam, but as it is saponifiable it would, therefore, seem advisable when treating cream to employ a low acidity.

Volatilization of an oil is dependent on its vapor tension. It is assumed that so violent is the natural vibration of the molecules that myriads are continuously expelled from the liquid, so forming vapor. The surface tension decreases as the temperature increases until, ultimately, the boiling point is reached. The boiling and evaporation intensity of a volatile oil depends upon its specific and latent heat and the pressure to which it is subjected. As the pressure is reduced so is the vapor tension of the volatile oil increased and the boiling point lowered. The fractions of the high boiling points are the most powerful in odor and flavor. In the case of cream, certain of the vegetable oils are more tenacious and noticeable in their contamination than others, for example those of turnips, rape, and onion. Oil of the wild onion is difficult to remove. Its characteristics are due to the presence of sulphur compounds, mainly allyl-propyl disulphide, and the higher fractions of the oil contain the more pungent flavoring principles.

To effectively remove vegetable oils, therefore, requires:-

(1) The evaporation of the volatile fractions by boiling.

(2) The solution of soluble substances by steam.

(3) The entrainment of non-volatile, insoluble principles in steam.

This means that the cream must be subjected to intense boiling, during which each fat globule and the colloidal caseion is effectively "scrubbed" by steam. The use of vacuum enables the necessary intense boiling to be carried out at temperatures sufficiently low to avoid damage to the cream, yet sufficiently high to be of definite pasteurizing value.

The cream, upon leaving the pasteurizing section, passes through the equilibrium valve into the first separating chamber. Centrifugal force is automatically produced in these chambers, occurring as the cream enters the top of the chamber at high velocity at a tangent, and is utilized to separate the boiling cream from the vapors and gases as it spirals down the sides of the separating chamber.

In the process of removing the feed flavors present, the principles involved in steam distillation are used. Steam, which was utilized in the pasteurizing unit to heat the particles of cream to the pasteurization temperature, is now used in the two separating units to wash away the adsorbed flavors which cling to the fat globules at the inter-face. This is brought about by the increased vacua which lower the boiling points so that the steam is regenerated from the cream and drawn off into the ejector-condenser, carrying with it the volatile fatty acids, some products of bacterial action, vegetable oils and chemicals, air and gases which contaminate the cream. The still farther increased vacuum in the second unit intensifies this action and is utilized also as a cooling treatment.

The extent of treatment which any given lot of cream receives to remove feed flavors from it is designated by two factors which can be regulated separately to suit the immediate needs. These are, the vacuum to which it is subjected, and the extent of steam washing.

As in steam distillation, higher temperatures must be used for the volatilization of various substances than for others, so also the boiling temperatures in the separating units may be varied to intensify or moderate the treatment of various creams by regulation of the vacuums. The intermediate vacuum is normally not higher than 20 inches (approximately 160°F.) nor lower than 15 inches (approximately 180°F.). The careful selection and application of a temperature best suited for the particular vat of cream being treated is of paramount importance.

The extent of steam washing, or the cleansing intensity, is altered by varying the amount of steam applied. Extensive research has revealed that no harm whatever is done to cream by an excessive use of steam.(15)

Since the washing steam heats the condenser water, the amount used can be gauged by the temperature differences between the water entering the condenser and the water leaving the condenser. From this, a treatment intensity figure is derived which may be used to determine the exact extent of such treatment the cream is receiving. This in calculated as follows:-

$$\frac{\text{Pounds weight of condenser water per hour} \times \text{Temperature rise of condenser water}}{\text{Pounds weight of cream per hour}} = \text{Intensity Figure}$$

Such a figure, of course, is dependent upon the tenacity of the feed flavors present.

In the vacuum cooler, the vacuum is always kept as high as possible. This is extremely important since it means additional removal of off flavors, reduction of dilution, improvement of flavor, cooling, and less pump friction and, therefore, less buttermilk losses.

Advantages of cooling in vacuum

During vacreation, the cream is cooled in vacuum to approximately 90° to 100° Fahrenheit.

Hunziker (9) stated that running hot cream directly from a flash pasteurizer into a coil vat and cooling is feasible, but not very satisfactory. Slow cooling between melting and solidifying points (95° to 65° F.), with prolonged agitation and exposure, promotes crystallization of the butterfat and a tendency toward a mealy texture in the resulting butter. Therefore, a surface cooler is usually used.

The chief objections to a surface cooler are, the danger of recontamination of the cream and exposure of the cream when hot to light and air while flowing in a thin layer over metallic surfaces. This exposure invites oxidation and may lead to the development of metallic, tallowy, or fishy flavors. The extent of such damage is largely dependent on the temperature of the cream. Danger of execessive oxidation is negligible at temperatures below 140° F. and, therefore, to be avoided, the temperature of the cream must be lowered to below 140° F. before passing it over the cooler.

Therefore, by instant lowering of the cream temperature to approximately 98° F. by vacreation, prior to passing it over the surface cooler, the danger of excess oxidation and impaired texture is reduced to a minimum.

ADDITIONAL ADVANTAGES DUE TO VACREATION

The general conditioning of the cream

The general conditioning of the cream is accomplished by concentration, cooling, and sweetening by high vacuum, and is brought about in the two separating units, although principally in the **second.** The added sweetness which is to be noted in the vacreated cream is thought to be due to a possible slight inversion of the milk sugar in the cream. (13)

Objectionable Butter Flavors

The objectionable flavors which are found in cream and which reappear in butter are of an extremely varied nature. The Revised Tentative United States Standards (1939) for the Quality of Creamery Butter (16) classifies the flavors in butter into six groups, depending on their character and origin. These groups are :-

1. Flavors from the action of microorganisms.
2. Flavors from mechanical causes.
3. Flavors from chemicals and chemical changes.
4. Flavors caused by feed conditions.
5. Absorbed flavors and odors that are throughout the mass of butter.
6. Flavors of obscure origin.

Hammer (4) found the flavors produced in milk and cream by microorganisms are extremely varied and dependent largely on the kind of organism present and conditions surrounding its growth.

An "acid" flavor is the most common but many others are frequent. Flavors such as "feedy" or "barny," that suggest other causes may be due to organisms. Such specific flavors as "soapy" and "turnipy" are occasionally due to the activity of organisms. A "malty" flavor may be due to the presence of Streptococcus lactis var. maltigenes. Escherichia-Aerobacter organisms frequently are the cause of "unclean" flavors. A "bitter " flavor may be due to a variety of organisms such as the lactose fermenting yeast-Torula amara, or to Streptococcus liquefaciens. A "bittermoldy" flavor may be due to Actinomyces organisms. Fishiness of milk and cream has been found to be due in some cases to microorganisms; and Pseudomonas graveolens and Pseudomonas mucidolens have been known to produce a "potato" odor in milk.

Pasteurization, properly done, benefits the flavor of the butter by the removal of volatile fatty acids and the destruction of bacteria. (9) Improper pasteurization, however, due to improper control of the metal heating surfaces, may result in such undesirable flavors as "cooked" and "scorched."

A "greasy" flavor is usually caused by improper pasteurization or to improper churning technique. (17)

Enzymes are present in butter in very small amounts (9) and their well know function of accelerating decomposition renders their presence undesirable. These enzymes may be of two sources; namely, those secreted in the milk, and those due to bacteria. According to their functions, they are grouped into three classes; lipolytic or fat splitting (lipase), Proteolytic or casein splitting (galactase), and oxidizing (peroxidase and catalase). Lipase and galactase produce bitter flavors while accelerated oxidation may result in such flavors as "fishy" and "oily", "metallic", "oxidized" or "storage".

Improper neutralization may result in an objectionable flavor known as "neutralizer." This flavor may vary from "soapy" to "bitter", dependent upon the type and amount of neutralizer used. A "scorched neutralizer" flavor may also result from improper neutralization of extremely sour cream.

Feed flavors are imparted to milk through the bodies of the cows and are due to the feeds consumed by the producing animal (4) They may also be absorbed from the atmoshphere surrounding the milk or cream. The most prominent feeds and weeds, from the standpoint of their effect on butter, are wild onion, garlic, leek, and Scale or French weed. Tar weed, mustard, alfalfa, silage, turnips, rape, cabbage, kale, clover, beets, and potatoes are also likely to cause pronounced flavors.

Odors are readily absorbed by milk, cream, and butter. Gasoline, fly-spray, disinfectant (4), cellar, musty, barny, cowy, feed, and woody flavors (17) may be due to absorption.

"Coarse," "smothered," "flat," or "heated cream" flavors are classified as of obscure origin because it is impossible to state their source. (17)

pH Values

A knowledge of the pH value of butter appears to be useful in the checking of manufacturing methods. Beatson, O'Dea, and Sargent (2) find that if the pH value of the butter falls below pH 6.5, the keeping quality is impaired. Other investigators (21) find that for storage purposes, the pH value should not be more than 6.8 or less than 6.1, since undesirable flavors such as those associated with oxidation develop at values above pH 7, and those associated with rancidity below pH 6.1.

Outline and Procedure of the Experimental Work

Purpose

The purpose of the research was to investigate the problem of feed, weed, and other objectionable flavors in butter and the application of the process of cream treatment known as "Vacreation" for the possible prevention or elimination of such flavors.

Procedure

(1) Butter was made regularly through the six months period (October 14, 1938 to April 15, 1939) from the normal supply of the Oregon Dairy Products Laboratory and at times from cream sent in from various parts of the state.

(2) At all times where cream was treated for the purpose of this research, "split" churnings were made. By this is meant that a vat of cream, after thorough mixing and neutralizing, was divided into two equal parts. One portion was vacreated, and the other pasteurized by the usual coil vat method. The same churn was used for churning the butter made from the non-vacreated cream. The vacreated cream was, in all instances, churned prior to the non-vacreated.

(3) After vacreation the cream was passed over the water section of a tubular cooler and run into the holding vat at about 60° to 70° F. If no starter was added,

it was passed over both the water and the brine sections of the cooler before being run into the holding vat where it was held at approximately 40°F.

(4) Butter was made both with and without starter so that both the control and the vacreated churnings made from the same vat of cream contained or did not contain starter. When starter was used, the starter added to the control vat was from the same batch as was added to the vacreated vat. Approximately 5 per cent of starter was added in any instance where starter was used.

(5) Acidities, churning temperatures, churning technique, percentage of salt, percentage of moisture and all the factors were regulated so that they were nearly the same in both the control and vacreated churnings. Vacreation treatment was varied from time to time as the character and quality of the cream demanded.

(6) All references as to cream quality, acidities, neutralization, starter, churning temperatures, churning technique, and all vacreation data were observed and recorded.

The examination of the cream included determination of the numbers of microorganisms by the standard plate count method. This was done on a majority of the samples.

After the cream was placed in the vat, neutralized, and thoroughly mixed, a sample was taken. The vat of cream was then "split." One half was pasteurized in the Vacreator at temperatures ranging from 190° to 200° F.; and the other half was pasteurized by the holding system at temperatures from 150° to 158° F. for 30 minutes.

A sample of each was takem immediately after pasteuization was completed. These were then plated on standard nutrient agar and incubated for 48 hours at 98.6 F. Dilutions of 1/10,000, 1/100,000, and 1/1,000,000 were made of the raw cream; and dilutions of 1/100 and 1/1,000 were made of each of the two pasteurized creams.

Examination for yeasts and molds, by plating on malt extract agar was also carried out until January 6, 1939 when it was discontinued. In no instance up to that time had any of the yeasts or molds found to be present in the raw cream survived either form of pasteurization.

(7) From every control churning and from every vacreated churning, four one-pound samples of standard shape were taken. These samples were wrapped inparchment; and one sample of each sample was over-wrapped with aluminum foil. All samples were numbered in such a manner as to disguise their origin from the judges grading the butter. The pairs of samples over-wrapped with the aluminum foil were stored at 0° to 10°F. and the other samples wrapped in parchment only and placed in waxed one-pound butter cartons were stored in the

ordinary cold storage room.

(8) The butter was scored in pairs, as indicated by the split churnings, at the Experiment Station and in the Monthly Butter-scoring Service. Scores from butter sent to the Interstate Associated Creameries were also recorded.

Butter was scored weekly at the Experiment Station. Pairs of the samples wrapped in parchment were scored as "fresh" and as "one month old." Four months after the end of the month during which the samples for the cold storage were made, they were taken out and scored. Judges participating in this scoring were Dr. G. H. Wilster and H. P. C. Nielsen of Oregon State College; F. F. Moser, of Medo-land Creamery, Corvallis; D. R. McIntosh, of Green Valley Creamery, Corvallis; and F. S. Board of Auckland, New Zealand. At least one pair of fresh samples from each week's churnings was sent to the Oregon State Agricultural College Monthly Butter Scoring Service. Here the butters were graded in pairs and a majority score for each sample was determined. Criticisms were recorded.

Judges participating in this grading were Messrs. R. S. Smith, United States Department of Agriculture; O. G. Simpson, Oregon State Department of Agriculture; R. E. Cavett, Ideal Dairy Co., Portland; M. J. Endres, Mt. Angel Creamery, Mt. Angel; G. W. Jacobsen, Lucerne

Cream and Butter Co., Portland; and L. Hammack, Raven Dairy, Portland.

During this period, all butter sent to the Interstate Associated Creameries, Portland, were labeled according to origin and all gradings and criticisms recorded accordingly.

Results and Conclusions

The Effect of Pasteurization on the Bacteria, Yeasts, Molds Table Number 1 shows the results of this research with regard to the destruction of bacteria.

Counts for the vacreated cream ranged from 100 to 6,500 bacteria per cc. The average count was 1,363 bacteria per cc. This represents an average bacteria killing efficiency of 99.9996 per cent.

In the cream pasteurized by the holding method, the counts ranged from 800 to 50,000 bacteria per cc. with an average of 19,413 bacteria per cc. This represents an average killing efficiency of 99.801 per cent. This making a difference of 0.1986 per cent in favor of vacreation.

Numerically, the non-vacreated cream contained an average of 14 times as many bacteria surviving pasteurization, as did the vacreated cream. Or, in per cent, of the total number of bacteria surviving either type of pasteurization, only 7.02 per cent were contained in the vacreated cream. The remaining 92.08 per cent being in the non-vacreated cream.

A noticeable difference was noted in the rate of growth of the colonies on the plates from the two types of cream. In general, colonies from the vacreated cream developed much more slowly than those from the non-vacreated cream. No difference was noted in the types of colonies present on either plates.

The effect of pasteurization on the destruction of the various enzymes found in cream was not determined in the scope of this research. The destruction of lipase by vacreation was thought to be indicated, however, when, during a period when lipase flavored cream was regularly encountered by the cream graders, a bitter flavor similar to that caused by lipase was more often encountered in the non-vacreated than in the vacreated butter. These results are indicated on the criticisms of butter sent to the Interstate Associated Creameries, where they were scored by the federal graders.

The effect of pasteurization on the yeasts and molds is shown in Table Number 2. In no instance, up to January 6, 1939 when yeast and mold plating was discontinued, did any of the yeasts or molds found from time to time in the raw cream survive either type of pasteurization.

Table No. 1

Effect of Pasteurization on Number of Bacteria Present.

	Raw Cream	Holding Method		Vacreation Method	
Date of Mfg.	Bacteria/cc.	Temp. °F.	Bacteria/cc.	Temp. °F.	Bacteria/cc.
(1938)					
Oct. 19	6,500,000	152	---	200	200
" 21	6,000,000	155	---	190	200
" 26	11,000,000	150	---	190	300
" 31	65,000,000	152	50,000	190	1,000
Nov. 2	24,000,000	152	14,000	190	2,900
" 5	59,000,000	150	26,000	190	6,500
" 11	69,000,000	152	29,000	200	1,200
" 16	80,000,000	152	7,000	190	2,000
" 21	65,000,000	152	22,000	200	400
" 23	40,000,000	152	46,000	200	5,000
" 26	55,000,000	152	44,000	200	---
" 30	52,000,000	152	6,000	200	2,000
Dec. 2	136,000,000	152	23,000	200	---
" 7	118,000,000	155	12,000	200	400
" 12	24,000,000	155	18,000	200	400
" 14	67,000,000	155	17,000	200	1,000
" 16	24,000,000	155	18,000	200	700
" 23	75,000,000	155	18,000	200	---
" 20	61,000,000	158	3,000	200	500

Table No. 1 (Cont'd.)

Date of Mfg. (1939)	Raw Cream Bacteria/cc.	Holding Method Temp. °F.	Holding Method Bacteria/cc.	Vacreation Method Temp. °F.	Vacreation Method Bacteria/cc.
Jan. 3	185,000,000	150	---	200	1,000
" 9	50,000,000	155	6,000	200	800
" 13	120,000,000	155	25,000	20	1,200
" 20	56,000,000	155	800	200	400
" 25	56,000,000	150	6,000	200	500
" 27	44,000,000	155	4,000	200	100
March 3	23,000,000	152	21,000	190	300
" 8	40,000,000	150	18,000	200	300
" 15	38,000,000	---	36,000	200	300
" 17	35,000,000	155	31,000	200	800
" 22	27,000,000	155	40,000	200	100
" 24	130,000,000	154	14,000	190	700
April 3	68,000,000	155	17,000	190	1,200
" 5	50,000,000	157	6,000	200	200
" 14	42,000,000	155	12,000	200	300
Average	59,442,857		19,413		1,363
Average killing efficiency			99.801%		99.9996%
Difference			.1986		

Table No. 2

Effect of Pasteurization on Number of Yeasts and Molds Present

Date of Mfg. (1938)	Raw Cream Count/cc.	Holding Method Count/cc.	Vacreation Method Count/cc.
October 19	200 yeasts	0	0
November 2	100 molds	0	0
" 5	300 yeasts	0	0
" 11	300 yeasts	0	0
" 16	500 yeasts	0	0
" 21	100 molds	0	0
" 23	100 yeasts	0	0
" 30	300 yeasts	0	0
December 2	200 yeasts	0	0
" 7	1200 yeasts	0	0
" 9	100 yeasts	0	0
" 14	300 yeasts	0	0
(1939) January 3	400 yeasts	0	0
Average	315 yeast or molds	0	0
Average killing efficiency		100%	100%

Results of Weekly Butter Scoring

All the butter coming under this project was scored weekly as "fresh", "one month old," and "four months old" (cold Storage). All samples were scored in pairs as indicated by the "split" churnings. Although the butters were actually scored and criticized, results were compiled according to opinions "for" or "against," showing preference of the vacreated or non-vacreated butters.

Fresh

These butters were scored on the Monday or Tuesday of the week following the week of their manufacture.

Of 247 opinions, 177, or 71.7 per cent were in favor of the vacreated butter; 53, or 21.4 per cent, were for the non-vacreated butters; while 17, or 6.9 per cent, rated the pairing equally. This represents an average of 3.3 to 1 of opinions in favor of the vacreated butters and correlates closely with the opinions voiced in the other gradings.

One month old

These were scored after storage for one month at temperatures ranging from 40° to 50° F.

Of 113 opinions voiced, 48, or 42.5 per cent, favored the non-vacreated butters; 53, or 46.9 per cent, favored the vacreated; while 12, or 10.7 per cent, rated the pairing equally.

Whether or not these figures are of any significance in regard to keeping quality, is hard to determine. The fact that practically all of the opinions since March 1st, favor the vacreated butter may be of significance, however. It was about this time that the feed flavors were beginning to show an added intensity and the acidity of the raw creams was increasing.

Four months old (cold storage)

The superior keeping quality of the vacreated butter under cold storage conditions is plainly demonstrated here, when, of 49 opinions, all but five, or 90 per cent, favored the vacreated butter.

The following tables represent the opinions of the judges. Actual scorings and criticisms are listed on pages 86 to 92 in the appendix.

Table No. 3

Weekly Scorings of Fresh Butter

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Ratings Same
(1938)				
October	14	-	4	-
"	19	-	4	-
"	21	-	4	-
"	26	-	4	-
"	31	-	4	-
November	2	-	4	-
"	5	-	4	-
"	7	-	4	-
"	9	-	4	-
"	11	-	4	-
"	16	-	4	-
"	18	4	-	-
"	21	3	1	-
"	23	-	4	-
"	26	1	2	1
"	28	1	2	1
"	30	4	-	-
December	2	1	1	2
"	5	1	1	2
"	7	1	2	1

Table No. 3 (Cont'd.)

Weekly Scorings of Fresh Butter

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Ratings Same
(1938) December	9	1	3	-
"	12	2	2	-
"	14	-	4	-
"	16	3	1	-
"	19	3	1	-
"	21	1	3	-
"	23	1	3	-
"	26	2	2	-
"	28	4	-	-
"	30	-	4	-
(1939) January	3	1	3	-
"	6	1	3	-
"	9	3	1	-
"	11	4	-	-
"	13	-	4	-
"	16	2	2	-
"	18	-	4	-
"	20	2	2	-
"	23	1	3	-
"	25	-	4	-

Table No. 3 (Cont'd.)

Weekly Scorings of Fresh Butter

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Rating Same
(1939)				
January	27	-	4	-
"	30	-	4	-
February	3	-	4	-
"	6	-	5	-
March	1	1	2	1
"	3	2	2	-
"	6	-	4	1
"	8	-	5	-
"	13	-	2	3
"	15	2	2	1
"	17	-	4	-
"	20	-	4	-
"	22	-	2	2
"	24	-	2	2
"	27	-	4	-
"	29	-	4	-
April	3	-	4	-
"	5	-	3	-
"	10	1	2	-
"	12	-	4	-

Table No. 3 (Cont'd.)

Weekly Scorings of Fresh Butter

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Ratings Same
(1939)				
April	14	-	4	-
TOTALS		53	175	17

Table No. 4

Weekly Scorings of Butter One Month Old

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Ratings Same
(1938) November	11	2	1	1
"	21	1	2	1
December	2	-	2	2
"	9	1	3	-
"	12	4	-	-
"	16	2	1	1
"	19	1	2	1
"	21	-	3	-
"	23	2	1	1
"	26	3	1	-
"	28	3	-	-
"	30	4	-	-
(1939) January	3	-	3	1
"	6	3	-	-
"	9	3	1	-
"	11	3	-	-
"	13	1	4	-
"	16	3	-	-
"	18	-	3	-
"	20	-	3	-

Table No. 4 (Cont'd.)

Weekly Scorings of Butter One Month Old

Opinions of the Judges

Date of Mfg. (1939)		For Non-Vacreated	For Vacreated	Ratings Same
January	23	3	-	-
"	25	-	3	-
"	27	3	-	-
"	30	-	-	3
February	3	-	3	-
"	6	1	3	-
March	1	2	-	1
"	3	3	-	-
"	6	-	2	-
"	8	-	2	-
"	13	-	2	-
"	15	-	4	-
TOTALS		48	53	12

Table No. 5

Weekly Scorings of Butter Four Months Old

Opinions of the Judges

Date of Mfg.		For Non-Vacreated	For Vacreated	Ratings Same
(1938)				
October	21	-	1	1
November	2	-	2	-
"	5	2	-	-
"	7	-	2	-
"	9	-	2	-
"	11	2	1	-
"	16	-	2	-
"	18	-	3	-
"	21	-	3	-
"	23	-	3	-
"	26	-	3	-
"	30	-	3	-
December	2	-	3	-
"	5	-	2	-
"	7	-	2	-
"	9	-	2	-
"	12	-	2	-
"	14	-	4	-
"	16	-	4	-
TOTALS		4	45	1

Gradings of Fresh Butter at Interstate Associated Creameries

Seventy separate churnings are represented in these scorings. Of these, sixty samples consitute thirty pairs as indicated by the split churnings.

Average scores were, for the non-vacreated butter 91.25, and for the vacreated butter 91.89. Preference was shown for the vacreated butter when, out of the 30 pairs, it was scored higher than the non-vacreated 18 times. The non-vacreated only 5 times, while seven pairs showed both scored the same. This showed a preference of 3.6 to 1 for the vacreated butter.

Of the entire lot, 41 churnings were scored 92 or better. Twenty nine of the 38 vacreated churnings, or 76.3 per cent were in this class. Six of these scored 93. Only 12, or 37.5 per cent of the 32 non-vacreated churnings were scored 92 or better. Of these, just one scored 93.

Table No. 6

Scores of the Fresh Butter at Interstate Associated Creameries

	Non-Vacreated		Vacreated	
Date of Mfg.	Score	Criticisms	Score	Criticisms
(1938)				
November 30	91	Slight old cream Mild culture	92	---
December 2	--	----------------	92	Mild culture
" 5	93	Slightly sticky	93	---
" 7	92	Slight normal feed Slightly salvy	93	Slightly sticky
" 9	92	----------------	91	Def. smothered
" 12	91	Def. smothered	92	Mild culture
" 14	--	----------------	92	Def. cooked
" 16	92	Mild culture	92	---
" 19	92	Mild culture	92	---
" 21	91	Sl. bitter	91	Sl. bitter
" 23	91	Sl. bitter	92	Sl. Normal feed
" 26	--	----------------	91	Sl. bitter
" 28	91	Sl. bitter	92	---
" 30	91	Sl. bitter	92	---
(1939)				
January 3	91	Sl. bitter	92	---
" 6	91	Sl. bitter	92	---
" 9	--	----------------	92	Sl. coarse acid
" 11	92	Sl. normal feed	93	----

Table No. 6(cont'd)

Scores of the Fresh Butter at Interstate Associated Creameries

Date of Mfg. (1939)	Non-Vacreated Score	Non-Vacreated Criticisms	Vacreated Score	Vacreated Criticisms
January 13	91	Def. coarse acid	91	Sl. coarse acid
" 16	--	-----	93	-----
" 18	91	Def. normal feed	92	-----
" 20	91	Sl. bitter	92	Sl. gummy
" 23	91	Sl. old cream	92	-----
" 25	92	-----	91	Sl. old cream
" 27	--	-----	93	Mild culture
March 1	92	Mild culture	92	Sl. coarse acid
" 6	92	Mild culture	--	-----
" 8	--	-----	92	Mild culture
" 13	91	Sl. greasy Sl. sticky	93	Mild culture
" 15	92	Sl. normal feed	92	Mild culture
" 17	91	Sl. greasy	92	-----
" 20	91	Sl. greasy	92	Sl. sticky
" 22	91	Sl. greasy	92	-----
" 24	92	----	91	Sl. old cream
" 27	92	----	91	Sl. old cream
" 29	90	Def. old cream	91	Sl. bitter

Table No. 6(cont'd)

Scores of the Fresh Butter at Interstate Associated Creameries

		Non-Vacreated		Vacreated	
Date of Mfg. (1939)		Score	Criticisms	Score	Criticisms
April	3	--	------	92	------
"	5	91	Sl. old cream	92	------
"	12	91	Sl. old cream	90	Def. old cream
"	14	91	Def. coarse acid	---	------
Average		91.25		91.89	

Scorings of Fresh Butter by the Oregon State College Monthly Butter Scoring Service

Scoring in this lot represents 31 pairs or 62 individual churnings of butter. At least one pair from each week's churnings was scored by the service.

Of these 62 samples, 34 scored 92 or better. Vacreated butter showed 22 of 31 samples, or 71 per cent, scoring in this class, with two samples scoring 93. One vacreated butter scored 90, and was criticised as "neutralizer, slight old cream."

The non-vacreated butter showed 12 of 31 samples, or 39 per cent, scoring 92 or better, with two samples scoring 93. Only one sample scored as low as 90½, being criticised as being "slightly coarse."

As scored in pairs, the vacreated butter was preferred to the non-vacreated 16 times, to 5 times, 3.2 to 1, when the non-vacreated butter scored higher. Ten pairings resulted in equal ratings.

Average scores, correlating closely to the Interstate Associated Creameries Gradings, were 91.22 for the non-vacreated butter and 91.84 for the vacreated.

The low scores of the vacreated butter prior to November 2, were probably due to scorching pre-churning of the cream in a large feed pump. At that time, this pump was replaced by a smaller pump which, although it also caused a slight churning with very viscus creams, largely eliminated this defect.

Scorching reappeared in the early spring as the softer fats caused by new green feeds began to appear. This difficulty was over-come when a water-jet, which added a fine spray of water to the steam just prior to its entry into the vacreator, was connected March 21.

This water-jet evidently reduced any super-heating or unsaturation of the steam due to the short connection of the boiler.

Table No. 7

Scorings of Fresh Butter by the

Oregon State College Monthly Butter Scoring Service

Date of Mfg. (1938)		Non-Vacreated Score	Non-Vacreated Criticisms	Vacreated Score	Vacreated Criticisms
October	14	91	Sl. old cream	91	Def. normal feed
"	19	91	Def. coarse acid	91	Sl. scorched
"	21	91	Sl. gritty Sl. smothered	92	Sl. Normal feed
"	26	91	Sl. smothered	91	Def. normal feed Sl. gummy
"	31	91½	Def. normal feed	92	Sl. coarse acid
November	2	92	Sl. normal feed Sl. mealy	92	---
"	5	92	---	92	Sl. normal feed
"	7	91½	Sl. acid	91	Sl. acid
"	9	92	Sl. normal feed Sl. sticky	92	Sl. normal feed
"	11	92	Sl. normal feed	92	Sl. sticky
"	16	91½	Sl. normal feed Sl. over-worked	92	Sl normal feed Sl. over-worked
"	18	91	Sl. scorched	91½	Sl. normal feed
"	26	91½	Sl. normal feed	92	Sl. flat
"	30	93	---	92½	Sl. old cream Sl. normal feed
December	7	91	Sl. neutralizer Smothered	90	Neutralizer Sl. old cream
"	14	91½	Sl. old cream Sl. scorched Neutralizer	92	Sl. flat
"	26	92	---	91½	Feed, greasy
"	28	92½	Sl. normal feed	93	---

Table No. 7 (Cont'd.)

Scorings of Fresh Butter by the

Oregon State College Monthly Butter Scoring Service

Date of Mfg.		Non-Vacreated Score	Non-Vacreated Criticisms	Vacreated Score	Vacreated Criticisms
(1939)					
January	6	91	Feed, old cream smothered, gummy	92	Sl. feed, flat
"	11	92	Sl. coarse acid	91	Briny, coarse acid
"	18	91½	Feed, sticky	92	Sl. normal feed
"	25	93	---	93	---
February	3	92	Feed	92½	---
March	6	92	Sl. lacking in character	92	---
"	8	92	---	92½	---
"	13	91½	Sl. coarse	92	Sl. coarse
"	15	91½	Sl. coarse	91½	Sl. coarse
"	20	91½	Crumbly, Sl. feed	92	---
"	29	91	Feed, weed	92	Sl. coarse
April	5	91	Crumbly, feed briny, weed	92	---
"	14	90½	Sl. coarse	92	---
Average		91.22		91.84	

Alternations in Churning Technique for Vacreated Cream

Lower neutralization was found to be possible with vacreated cream. In conjunction with this, the vacreated cream normally showed acid readings from 0.01 per cent to 0.02 per cent lower than the boiled sample from the holding vat. This is thought to be due to the removal, by vacreation, of more of the volatile fatty acids and to the more efficient incorporation of the neutralizing agent, during the vacreation process. One batch of onion flavored cream was successfully neutralized from 0.5 per cent acid (calculated as lactic) to 0.05 per cent with very good results.

Vacreated cream showed less rise in temperature during over-night holding than did non-vacreated creams. This is probably due to the fact that there is less absorbed heat in the fat globules, resulting in easier regulation of the acidity during ripening.

Lower churning temperatures were required when churning vacreated cream. These temperatures varied from those used for the non-vacreated creams by from two degrees Fahrenheit in the winter to five degrees in the spring. The result was a smoother, firmer, more uniform body which was characteristic of the vacreated butters; and a better control of composition.

During the winter months water was incorporated into the non-vacreated butters more easily than into the vacreated. During the spring months, however, the vacreated butter required less working in the wash water than the corresponding non-vacreated. Consequently, the vacreated butter was in a firmer, more desirable condition, with less tendency toward greasiness, when removed from the churn.

The use of starter apparently made no difference except to impart its characteristics to both the vacreated and the non-vacreated butter.

Buttermilk Losses

Buttermilk losses were found to be considerably higher from the vacreated cream than from the non-vacreated.

The average buttermilk test for the non-vacreated cream was 0.48 per cent, and is representative of a total fat loss of 1.21 per cent. The vacreated cream showed losses approximately double those of the non-vacreated. The average buttermilk test for the vacreated cream was 0.87 per cent, or a total fat loss of 2.40 per cent.

When comparing these buttermilk losses, one would expect to find some degree of uniformity when using similar treatments with the same class of cream. Investigations, however, fail to reveal any correlation between intensity of treatment and the high buttermilk losses of the vacreated creams.

Several factors may have considerable bearing on this. Probably the most important of these is the dilution factor. Dilution due to vacreation amounts to about 3 per cent (20) of the total cream or a variation of 1 per cent in the butterfat, and is therefore of no consequence. Excessive dilution due to the small lots caused by the "split" churnings may be a decided factor here, since it diminishes the power of the milk solids to protect the fat globules against mutilation during churning. (8)

Table No. 8

Buttermilk Losses

Date of Mfg.		Vacreator Method B.M. Test	Vacreator Method % Total Fat Lost	Holding Method B.M. Test	Holding Method % Total Fat Lost
(1938)					
October	14	0.45	1.0	---	---
"	21	0.52	1.8	0.34	1.1
"	26	0.54	---	0.52	---
"	31	0.70	2.0	0.54	1.4
November	2	0.96	2.7	0.52	1.3
"	5	0.54	1.5	0.42	1.1
"	9	1.00	2.3	0.40	0.8
"	11	1.10	3.1	0.60	1.5
"	16	0.80	2.1	0.60	1.3
"	23	0.60	1.2	0.45	1.0
"	26	9.90	2.3	0.58	1.4
"	28	0.68	1.8	0.66	1.1
"	30	0.96	2.5	0.34	0.85
December	2	0.90	2.3	0.40	0.87
"	5	0.90	2.3	0.34	0.85
"	7	0.90	2.4	---	---
"	9	0.80	2.4	0.45	1.3
"	12	1.30	3.9	0.45	1.5
"	14	0.80	2.2	0.44	1.2
"	16	0.84	2.4	0.58	1.5
"	19	1.08	2.8	0.58	1.5
"	21	1.02	2.4	0.60	1.3

Table No. 8--Con't.

Buttermilk Losses

Date of Mfg.		Vacreator Method B.M. Test	Vacreator Method % Total Fat Lost	Holding Method B.M. Test	Holding Method % Total Fat Lost
December	23	0.88	2.4	0.60	1.4
"	26	1.06	2.5	0.46	1.1
"	28	1.20	3.6	0.46	1.3
"	30	0.64	2.0	0.46	1.6
(1939)					
January	3	0.60	1.7	0.40	1.0
"	6	0.74	1.9	0.48	1.1
"	9	0.98	2.9	0.66	1.8
"	11	1.00	2.8	0.48	1.2
"	13	1.00	3.2	0.45	1.3
"	16	1.00	2.8	0.44	1.2
"	18	1.00	2.6	0.48	1.2
"	20	0.80	2.1	0.40	1.0
"	23	0.90	2.6	0.48	1.5
"	25	0.92	2.1	0.56	1.4
"	27	1.00	3.1	0.62	1.5
February	6	0.80	2.8	0.42	1.2
March	1	0.60	1.7	0.45	1.1
"	8	1.00	2.9	0.48	1.2
"	13	0.82	2.2	0.52	1.4
"	15	1.00	2.5	0.45	1.1
"	17	0.70	1.7	0.52	1.3
"	20	1.12	3.3	0.46	1.2

Table No. 8--Con't.

Buttermilk Losses

Date of Mfg.		Vacreator Method B. M. Test	Vacreator Method % Total Fat Lost	Holding Method B.M. Test	Holding Method % Total Fat Lost
March	22	0.88	2.4	0.36	0.9
"	24	0.84	2.3	0.34	0.84
"	27	0.86	2.6	0.36	0.98
"	29	0.94	2.99	0.45	1.26
April	3	0.82	2.2	0.36	0.64
"	5	0.86	2.15	0.44	1.13
"	10	0.96	2.4	0.56	1.48
"	12	1.12	2.9	0.48	1.20
"	14	1.00	2.9	0.46	1.21
Average		0.87	2.40	0.48	1.21

The following data compiled under commercial conditions by F. H. McDowall, Dairy Research Institute, New Zealand (11), give results comparable to those obtained with common methods of pasteurization and are probably more accurate than those obtained herein, under experimental conditions.

Table No. 9

Details of the analyses of buttermilk from the five factories from which samples were obtained.

Factory	Number of days analyses made	Percentage of fat in buttermilk		
		Average	Maximum	Minimum
A.	27	0.76	0.88	0.64
B.	32	0.74	0.91	0.64
C.	31	0.72	0.81	0.63
D.	16	0.73	0.91	0.65
E.	29	0.89	1.01	0.73
	Ave.	0.768	0.904	0.658

Average fat in undiluted buttermilk 0.89

Factory	Number of days analyses made	Percentage of fat from cream, lost in buttermilk.		
		Average	Maximum	Minimum
A.	27	1.44	1.73	1.17
B.	32	1.48	1.68	1.27
C.	31	1.15	1.39	0.98
D.	16	1.39	1.59	1.28
E.	29	1.61	1.79	1.40
	Ave.	1.41		

Treatment of Cream Possessing Strong Obnoxious Feed Flavors

Special samples, representing ten and twenty gallon lots of intensely flavored cream, were handled separately.

During December, alfalfa flavored cream shipped to the Experiment Station for experimental work involving body and texture, was vacreated. In all cases this flavor was effectively removed.

Beginning in March, stronger flavors began to appear. Cream containing principally onion, and scale weed flavors were received from numerous parts of the state.

These samples were treated entirely by vacreation except for one-half gallon samples which were churned after pasteurization by the holding method in a small hand churn. The vacreated cream was churned separately or added to the regular vat, in which case a sample was churned.

Due to the condition of some of the cream before treatment, probably due to shipping conditions, the best results were unobtainable. Such flavors as "metallic" and "old cream", which constitute chemical changes in the fat, are not removed by vacreation, although their intensity may be modified.

Creameries sending samples were:

(1) Medo-land Creamery, Corvallis

(2) Farmers Cooperative Creamery, Carlton

(3) Wallowa County Creamery, Wallowa

(4) Lucerne Cream & Butter Co., Portland

(5) Union County Cooperative Creamery, Union

(6) Ideal Dairy Co., Portland

(7) Raven Dairy, Portland

Scored at the Experiment Station for flavor alone, the following results were obtained from these butters.

Table No. 10

Special Samples

Number	Source	Flavor	Method of Past.	Score
A	OSC	Weedy	Vacreator	91
B	OSC	"	Holding	90
1-a	1	Kale	Vacreator	92
2-a	1	"	Holding	90
3-a	2-3	Onion	Vacreator	92½
4-a	2	"	Holding	85
5-a	3	"	Holding	85
6-a	2	"	Vacreator	90½
7-a	2	"	Holding	85
8-a	2	"	Vacreator	91
9-a	2	"	Holding	85
10-a	2-3-4	Onion and Scale weed	Vacreator	92
11-a	2-3-4	"	Holding	85
12-a	---	Onion	Vacreator	92
13-a	---	"	Holding	85
14-a	3-5-6	Onion and Scale weed	Vacreator	91
15-a	3-5-6	"	Holding	85
16-a	3-6-7	"	Vacreator	92
17-a	3-6-7	"	Holding	85

Numbers 10-a and 11-a were scored at the Monthly Butter scoring service, 90½ and 86, respectively.

pH Values of Butter Serum

These values represent all butter scored since January 15, 1939. No apparent difference in the trend of these values, either in the fresh butter or in the storage butter, characterized the vacreated or the non-vacreated butter.

Average values indicated a slightly higher pH in the vacreated butter, in all cases. Vacreated butter gave the following values:--Fresh butter (January 9 to April 14, 1939) pH 6.150, one month old butter (December 12, 1938 to March 17, 1939) pH 6.119, and four months old cold storage butter (November 11 to December 16, 1938) pH 5.951. Non-vacreated butter for the same periods gave values of pH 6.052, pH 6.048, and pH 5.885 respectively.

Nineteen pairs of butter which showed values both as "fresh" and as "month old" showed an average drop in pH of 0.11 points for the vacreated butter and 0.10 for the non-vacreated. The vacreated butter dropped from an average of pH 6.14 to pH 6.03. Non-vacreated butter dropped from pH 6.05 to 5.95.

No check on the change of pH value was obtainable between the fresh and the cold storage butter, values for the fresh butter having no corresponding values for the same butter after four months in cold storage.

Lower values were commonly obtained when starter was used.

In two instances over-neutralization was indicated, coinciding with previous tests.

Table No. 11

pH Values of the Fresh Butter

Date of Mfg.	Vacreated	Non-Vacreated
(1939)		
January 9	5.70	5.60
" 11	6.40	6.20
" 13	6.40	5.70
" 16	6.00	6.00
" 18	6.30	6.20
" 20	6.20	6.10
" 23	5.80	6.00
" 25	5.90	6.00
" 27	6.10	6.20
" 30	6.85	6.50
February 3	6.50	6.50
" 6	6.10	5.95
March 1	6.00	5.90
" 3	5.65	5.75
" 6	7.00	6.60
" 8	6.90	6.50
" 13	5.70	5.85
" 15	5.60	5.80
" 17	5.60	5.60
" 20	5.60	5.70

Table No. 11 (Cont'd)

pH Values of the Fresh Butter

Date of Mfg.		Vacreated	Non-Vacreated
(1939)			
March	22	6.50	6.40
"	24	6.40	6.20
"	27	6.20	6.05
"	29	6.10	6.17
April	3	6.13	6.00
"	5	6.30	6.55
"	10	5.55	6.00
"	12	5.56	5.80
"	14	5.82	5.71
Average		6.150	6.052

Difference 0.098

Table No. 12

pH Values of Butter One Month Old

Date of Mfg.		Vacreated	Non-Vacreated
(1938)			
December	12	5.75	5.65
"	16	6.15	6.00
"	19	7.50	7.45
"	21	6.30	6.20
"	23	6.25	6.10
"	28	6.20	6.05
(1939)			
January	3	6.25	6.15
"	6	6.25	6.50
"	9	5.50	5.50
"	11	6.00	6.00
"	13	6.15	5.50
"	16	6.00	6.00
"	18	6.20	6.10
"	20	6.20	6.15
"	23	5.70	5.80
"	25	5.70	5.90
"	27	6.00	6.00
"	30	6.75	6.30

Table No. 12 (Cont'd.)

pH Values of Butter One Month Old

Date of Mfg.		Vacreated	Non-Vacreated
(1939)			
February	3	6.35	6.25
"	6	6.15	5.95
March	1	5.68	5.83
"	3	5.60	5.61
"	6	6.98	6.57
"	8	6.84	6.45
"	13	5.65	5.80
"	15	5.59	5.92
"	17	5.53	5.52
Average		6.119	6.048

Difference 0.071

Table No. 13

pH Values of Cold Storage Butters (4 months old)

Date of Mfg. (1938)		Vacreated	Non-Vacreated
November	11	6.20	6.00
"	16	5.70	5.60
"	30	5.78	5.71
December	2	5.64	5.55
"	5	6.05	6.01
"	7	6.15	6.03
"	9	6.30	6.28
"	12	5.50	5.50
"	14	6.14	6.12
"	16	6.05	6.05
Average		5.951	5.885

Difference 0.066

Summary

The preparation of cream for butter-making by Vacreation consists essentially of ultra-flash pasteurization by instant direct contact of the cream particles with steam of adjusted temperature in low vacuum; the removal of extraneous objectionable flavors by steam distillation in intermediate vacuum; and cooling and concentration of the cream in high vacuum.

An investigation into the problem of feed, weed, and other objectionable flavors in the butter, and the application of vacreation for their removal from cream, along with the pasteurization and general conditioning of the cream, was undertaken.

Butter was made over a six months' period from the regular supply of cream to the Oregon State College Dairy Products Laboratory, and at times from cream sent in from various parts of the state. "Split" churnings were made of all cream; one batch being vacreated, the other, pasteurized by the regular holding method, was run as a check.

Examination was made of (1) the fresh butter, (2) after holding the butter one month at 40° to 50° F., (3) and after holding four months at 0° to 10° F. Gradings favored the fresh vacreated butter 3.4 to 1, with 73.7 per cent of the vacreated and 38 per cent of the non-vacreated samples scoring 92 or better.

Butter held one month at 40° to 50° F. showed little difference between the vacreated or non-vacreated butter.

Cold Storage butter held four months gave results favoring the vacreated butters almost exclusively (90 per cent).

Special samples embodying cream possessing such intense flavors as "kale", "weed", "onion", and "scale weed" or "French weed" showed efficient removal of these flavors when the cream was treated by vacreation. Flavors such as "old cream", "oxidized", or "metallic", which were symbolic of chemical changes in the cream, and probably due to conditions in transit from various parts of the state, were not entirely removed, however.

Pasteurization by vacreation far surpassed pasteurization by the holding method. Counts ranged from 100 to 6,500 bacteria per cc. and averaged 1,363 bacteria per cc. for the vacreated cream. Similarly, counts ranged from 800 to 50,000 bacteria per cc. and averaged 19,413 bacteria per cc. for the holding method.

Average efficiencies of the destruction of bacteria were 99.996 per cent and 99.801 per cent respectively for pasteurization by vacreation and by the holding method. Yeasts and molds were destroyed with 100 per cent efficiency by both methods.

Alterations in churning technique showed lower neutralization and lower churning temperatures possible with vacreated cream; a smoother, firmer, and more uniform bodied butter resulted.

Although average pH values indicated a slightly higher active acidity in the non-vacreated butter in both the fresh and in the storage butter, no apparent difference in the trend of these values characterized the vacreated or the non-vacreated butter. The average drop in value during storage for one month at 40° to 50° F. was 0.11 for the vacreated butter, and 0.10 for the non-vacreated. No check was obtainable on butter held four months in cold storage.

Bibliography

(1) Associated Quarterly, 1:3, 1938, Dairy and Ice Cream Machinery and Supply Ass'n., Inc.

(2) Beatson, E. A., O'Dea, J., and Sargent, J.D., Extract from the Annual Report to the Dep't. of Scientific and Industrial Research, 1937-38, Dairy Research Insitute, New Zealand.

(3) Board, F. S., information personally extended.

(4) Hammer, B. W., Dairy Bacteriology, 2nd Ed., New York, John Wiley and Sons, Inc., 1938.

(5) Hammer, B. W., former students of, B. W. Hammer Panegyric, Ames, Iowa, Collegiate Press, Inc. 1937.

(6) Hammer, B. W., Process for Treating Lactic Fluids, Patent No. 2,022,420, U. S. Patent Office, Nov. 26, 1935.

(7) Horneman, H. C., Process for Pasteurizing and Deodorizing Liquids, Patent No. 2,022,419, U. S. Patent Office, Nov. 26, 1935.

(8) Hucker, G. J., and Alice M., The Grindrod Impact Sterilizer, New York State Agricultural Exp. Sta. (Tech. Bul. 155, 1929).

(9) Hunziker, O. F., The Butter Industry. LaGrange, Ill. The author 1920.

(10) Jensen Super-Deodorizer, advertising data by the Jensen Creamery Machinery Co. Inc.

(11) McDowall, F. H., special work on the analysis of buttermilk, Dairy Research Institute, New Zealand, 1936.

(12) Murray Deodorizers Ltd., Notes on the Basic Principles of the Murray Deodorizer Process.

(13) Murray Deodorizers Ltd., Vacreation--A New Process Based on an Old Method--advertising data.

(14) Murray Deodorizers Ltd., Vacreator Daily Log.

(15) Murray Deodorizers Ltd., Vacreator Manual, 3rd Ed.

Bibliography (Con't.)

(16) Murray Deodorizers Ltd., special advertising data, 1939.

(17) Revised Tentative U. S. Standards for the Quality of Creamery Butters, U. S. Dep't. of Agri. 1938.

(18) Rogers High Temperature Cream Pasteurizer, advertising data by C. E. Rogers Co.

(19) Rogers, L. A., associates of, Fundamentals of Dairy Science. 2nd ed. New York, Reinhold Publishing Corp. 1935.

(20) Smith, J. Wallace, Paper for Factory Managers Conference, Wellington. Feb. 17, 1937.

(21) Stein, R. W. Meaning and Significance of pH with Reference to Butter, special report, Oregon State College, 1939.

(22) The Taranaki Daily News (New Zealand), Special Dairying Supplement, Oct. 13, 1936.

(23) Wilster, G. H., Practical Butter Making, O. S. C. Cooperative Ass'n. (1937)

(24) Wilster, G. H., and Nielsen, H. P. C., Influence of Different Pasteurizing Temperatures in Killing Bacteria, Yeasts, and Molds in Cream, report of Second Annual Conference in Buttermaking, Interstate Associated Creameries, 1938.

Appendix

Weekly Scoring of Fresh Butter

	Holding Method		Vacreator Method	
Date of Mfg. (1938)	Score	Criticisms	Score	Criticisms
October 21	91	Old cream, briny, neutralizer, feed	93	---
" 26	91½	Sl neutralizer sl old cream	92½	Flat, cooked
" 31	91	Sl. neutralizer sl. old cream	92½	---
November 2	91½	Sl. neutralizer sl. old cream	93	---
" 5	92	Sl. coarse, feed	93	---
" 7	91½	Old cream	92½	Sl. flat old cream
" 9	91	Old cream, feed	93	---
" 11	91½	Old cream, feed	92½	Flat
" 16	92	Sl. old cream, feed, sl. briny, sl. coarse	92½	---
" 18	91½	Coarse, feed, sl. old cream, musty	92½	Flat
" 21	92	Feed, sl. old cream	91½	Sl. coarse, feed, wintry
" 23	92	Feed, briny, sl. coarse	92½	Flat
" 26	92	Feed, flat, sl. briny	92½	Flat, sl. feed sl. coarse
" 28	92½	Feed, sl. old cream	92½	---
" 30	93	---	92½	Briny, sl. bitter
December 2	92½	---	92½	Sl. feed

Table No. 14 Continued

Weekly Scoring of Fresh Butter

Date of Mfg.	Holding Method Score	Holding Method Criticisms	Vacreator Method Score	Vacreator Method Criticisms
December 5	92½	---	92½	Feed
" 7	92	Feed, sl. briny, sl. old cream, sl. scorched	92½	Feed, bitter
" 9	92	Sl. neutralizer, feed, old cream	93	---
" 12	92	Feed	93	Feed
" 14	92	Bitter	92½	---
" 16	93	Sl. feed	92½	Sl. feed
" 19	92½	Sl. feed	92	Feed
" 21	92	Coarse, feed, sl. neutralizer	92½	Sl. feed
" 23	92	Sl. feed	92½	Feed, wintry
" 26	92	Sl. storage sl. neutralizer	92½	Feed, storage
" 28	92½	---	92	Sl. feed
" 30	92	Feed, sl. old cream	92½	---
(1939) January 3	92	Feed	93	---
" 6	92	Sl. old cream, feed	92½	---
" 9	92½	---	92½	---
" 11	93	---	92	Feed, briny
" 13	91½	Sl. bitter, feed, old cream	93	Sl. flat, feed
" 16	92½	Feed, sl. old cream	92½	Coarse, feed
" 18	92	Coarse, briny, stale cream	92½	---

Table No. 14 Continued

Weekly Scoring of Fresh Butter

Date of Mfg.	Holding Method Score	Holding Method Criticisms	Vacreator Method Score	Vacreator Method Criticisms
January 20	92½	---	92½	---
" 23	92	Feed, old cream, coarse	92½	---
" 25	92	Coarse, sl. feed	93	---
" 27	92	Sl. coarse, sl. acid	92½	---
" 30	92	Coarse, neutralizer	93	---
February 3	92	---	93	---
" 6	92	Lipase, coarse	93	Feed
March 1	92	---	92½	---
" 3	92½	---	92½	Coarse
" 6	91½	Coarse, storage	92½	Briny
" 8	91½	Sl. feed, briny, sl. coarse	92½	---
" 13	92	---	92	High flavor, coarse, sl. acid
" 15	92	---	92	Sl. coarse, old cream, sl. feed
" 17	91½	Sl. old cream, feed, coarse	92½	Cooked, sl. high acid
" 20	91½	Old cream, feed, briny, coarse	92½	---
" 22	92	Old cream, feed	92½	Briny
" 24	91½	Neutralizer, feed, old cream, heated	92	Old cream, feed, sl. scorched
" 27	91	Sl. old cream, feed, coarse	92½	Sl. cooked

Table No. 14 Continued

Weekly Scoring of Fresh Butter

Date of Mfg.	Holding Method Score	Holding Method Criticisms	Vacreator Method Score	Vacreator Method Criticisms
March 29	91	Sl. old cream, pronounced feed	92	Sl cooked, sl, briny
April 3	91	Sl. old cream, pronounced feed, sl.coarse, sl. briny	92	Sl. cooked, sl. briny
" 5	91½	Sl. old cream, feed	93	---
" 10	92	Normal feed	92½	---
" 12	90	Pronounced feed, old cream	92	Feed, sl. old cream
" 14	90½	Pronoumced feed, sl. old cream	92	---
Average	91.86		92.51	
Difference		0.65		

Summary

	Holding Method	Vacreator Method
93 score	3	13
92½ score	9	35
92 score	27	10
below 92 score	20	1
92 score or above	39, or 67.8%	58, or 98.3%
Below 92 score	20, or 32.2%	1, or 1.7%

Table No. 15

Weekly Scoring of Butter One Month Old

	Holding Method		Vacreator Method	
Date of Mfg.	Score	Criticisms	Score	Criticisms
(1938) November 11	91½	Feed, wintry	91½	Sl. storage
" 21	91½	Sl. storage	92	Briny, stale
December 2	92	Storage	92½	---
" 9	91½	Neutralizer	92	Storage
" 12	92	Sl. feed, storage	91	Storage, sl. old cream
" 16	92	Sl. storage	91½	Bitter, sl. storage
" 19	91½	"	92	Sl. storage
" 23	92	"	92	"
" 26	91½	Storage	91½	Storage, coarse, old cream
" 30	91½	Sl storage, sl. coarse	91	Old cream, bitter, storage
(1939) January 3	91½	Sl. storage	91½	Sl. storage
" 9	92	"	92	"
" 13	92	Sl. storage, coarse	92½	----
" 16	91½	Storage	90	Sl. rancid
" 18	90	Sl. rancid	91½	---
" 20	91	Sl. storage	91½	Storage
" 23	92	"	90	Sl. fishy
" 25	91	"	91½	---
" 27	91	Old cream, storage	90	Sl. rancid
" 30	91	Storage	91	Storage

Table No. 15 Continued

Weekly Scoring of Butter One Month Old

	Holding Method		Vacreator Method	
Date of Mfg.	Score	Criticisms	Score	Criticisms
February 3	90½	Storage	91½	---
" 6	90½	"	91½	---
March 1	91	Bitter, sl.rancid	90	Bitter, sl.rancid
" 3	92	---	90	Undesirable aroma
" 6	91½	---	92	---
" 8	91	---	92	---
" 13	91	Feed, sl. storage	92	---
" 15	91½	Sl. old cream	92½	---
" 17	91½	Old cream	92½	---
Average	91.39		91.47	
Difference		0.08		

Summary

	Holding Method	Vacreator Method
92 score, or above	8, or 27.59%	13 or 44.82%
below 92 score	21 or 72.41%	16 or 55.18%

Four of the vacreated samples scored 92½. None of the non-vacreated scored over 92.

Table No. 16

Weekly Scoring of Butter Four Months Old

Date of Mfg. (1938)	Holding Method Score	Holding Method Criticisms	Vacreator Method Score	Vacreator Method Criticisms
October 21	89½	Storage	90	Storage
November 2	90	Storage	91	"
" 5	90½	"	89	Sl. fishy
" 7	90	"	91	Storage
" 9	90	"	91½	Sl. storage
" 11	91	"	90	Sl. oily
" 16	90	---	91	---
" 18	91	Storage, briny	92	Storage, briny sl. scorched
" 21	91	Old cream, storage	92	Sl. storage
" 23	91	" "	92	"
" 26	90½	" "	91½	Storage
" 28	91½	Storage	90	Sl. oily
" 30	91	Storage, old cream	91½	Storage
December 2	91	Sl. storage	91½	Sl. storage
" 5	91	Storage	92	---
" 7	90½	Storage, feed	92	---
" 9	90½	" "	92	---
" 12	90½	" "	92	---
" 14	91½	Sl. old cream	92½	---
" 16	91	Old cream, storage	92	---
Average	90.650		91.325	
Difference		0.675		

92 score or above   Holding method none, Vacreation nine.
below 92   Holding method twenty, Vacreation eleven.