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THE PROCESS OF VACREATION

Technical papers presented at the Short Course in Vacreation, Oregon State College, September 1948

Department of Dairy Husbandry

AGRICULTURAL EXPERIMENT STATION
Oregon State College
Wm. A. Schoenfeld, Director
Corvallis

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Oregon State College

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P. R. Elliker, Bacteriologist

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OPENING REMARKS

by

M. P. Monroe, President
Monroe Dairy Machinery, Inc.

Members of the Oregon State College Faculty and fellow students:

If you wish to be seen, stand up. If you wish to be heard, speak up. If you wish to be appreciated, shut up. I will limit my remarks accordingly.

The Short Course we are attending is precedent making. This is, I believe, the first time the College has donated its facilities and its faculty for the use of a sales organization. This service from the College obligates us to do all we can to assure the success of this Vacreator Short Course.

For the next three days we are college students. If any of you Betas brought your fraternity pins along, put them on. You can also drag out your rooters' lids. Most of us keep a record of our scholastic work. This is a regular College Short Course, condensed, with lots of meat in it. This, you can use accordingly and to your advantage.

To enable those on the program to utilize the time allotted to best advantage, to insure full coverage of the subjects to be discussed and to avoid embarrassment and confusion, let's make it a point to be in our seats, set and ready to go at the time each lecture is scheduled to start.

I take this opportunity to express the appreciation on behalf of Monroe Dairy Machinery, Inc. to Dr. Brandt, Dr. Wilster and other members of the Oregon State College Faculty for providing the facilities of the College and for giving their time and effort in making the Short Course possible.

I know in part the time Dr. Wilster and Dr. Brandt have devoted to putting on this program. They have put in many days of work since the decision to hold the Short Course was first arrived at some six months ago.

We appreciate also the time devoted to this session by the other members of the Oregon State College Faculty in preparing their material for presentation.

Harvey Behlmer has traveled all the way from Chicago to give his time and efforts in our behalf and Charlie Miller and Roy Stout have worked hard to make the meeting a success.

We appreciate also the Taylor Instrument Company's interest in this program. I am not mentioning Frank Board in this category -- he will take his credit in Vacreator orders.

Now as regards the subject assigned to me, "The Purpose of the Short Course." It is obvious, in discussing Vacreators among ourselves, that with the exception of two or three individuals in our organization, we are not on as familiar ground as we would be if we were discussing other types of equipment. Likewise, we are not as prone to discuss the Vacreator with the trade. We, too, are limited in our knowledge of what the machine will do to improve the product.

Certainly this is the right place to get Vacreator atmosphere as I am sure Frank Board looks upon the Dairy Department of Oregon State College as the "home field."

If you examine the Short Course schedule, you will observe that the course includes detailed discussion on subjects relative to the operation of that machine. We will receive material on such subjects as steam supply and distillation, discussion on pasteurization, its effect on yeast and molds, physics, water supply and treatment, boilers and controls.

Certainly, with the subjects that we will hear discussed and the wealth of talent in the capacity of instructors, we should all leave the meeting materially better qualified to sell and service Vacreators.

Remarks by P. M. Brandt

"Gentlemen:

I have known both Monte and Wendell Monroe since their Oregon State College student days. Before them, there was a very warm feeling for their father. We had Monte's son with us last year. Thus, you see, there is a sort of three-generation acquaintanceship background with the Monroe family which partially accounts for the very complimentary introduction I just received.

The normal procedure in starting a class at the beginning of the year is to call the roll from the registration cards. We thus quickly become acquainted with our students. We have no class cards today and most of us are as unacquainted as if we were a class of freshmen. To start this thing off right, will you please introduce yourselves, giving your name and residence? (Thirty-three were present from Oregon, Washington, Utah, Idaho, California, and Illinois. List of those present may be found in the registration book.)

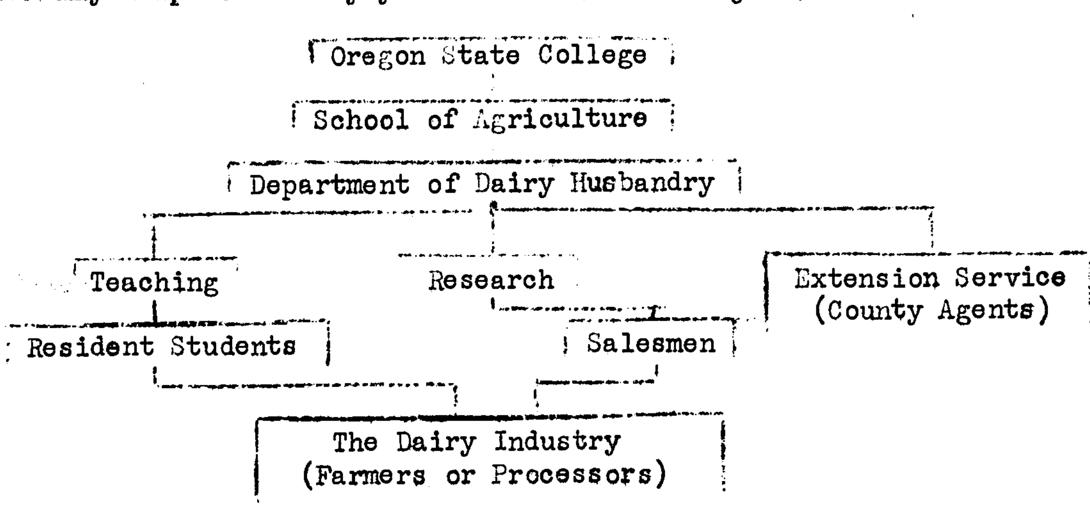
You told us, Mr. Monroe, that you would have a wide representation here but I must confess that I did not realize it would be as extensive as it is and that our attendance would range from Chicago to Los Angeles. It is gratifying to know that the representation is so extensive.

My job is to orient you with the program of this short course. This is a short course of unusual type. It is not customary for a land-grant college to put itself in a position to possibly be accused of showing preference for a particular piece of equipment, machinery, or laboratory apparatus. But we may be in that position in the eyes of some people. Because of the unprecedented character of this course, authorization to conduct it was obtained only after careful consideration by the Dean of the School of Agriculture. We are establishing a real precedent when we offer a short course for the purpose of demonstrating or elaborating on the use of a particular kind of equipment exclusively sold by one manufacturer or sales organization. The difference is that, in this instance, we are primarily demonstrating a method which happens to be inseparable from a particular machine or piece of equipment. We recognize in the Vacreator the use of a method which, from our experience and observation of its use, we know to be beneficial to the improvement of dairy products to such an extent that we feel justified -- because of our responsibility to the producers of milk on farms -- in taking the chance of being put in the position referred to previously. Again, I emphasize that the process is the thing in which we are interested. It is not our fault that presently the process is only in this particular machine.

That emphasizes to me the importance of you people, as representatives of this organization, understanding fully what this method can do and what it can't do -- that is what we will attempt to make clear to you during the next three days.

I marvel at the involved processes and equipment now used in our modern dairy manufacturing plants. Recently I observed a milk plant at Oak Park near Chicago. I stood on the balcony with one of the officials, who happened to be a college classmate, and admired the mechanics of the plant: sanitation - light- orderliness - the complicated and automatic type of operation. Observing the applications of physics, of chemistry, of bacteriology, and of engineering, I said to my friend, Otto Schrenk, "How in the world do you ever keep on top of this job?" He replied, "I don't try to. In the first place, it is not in my department. Secondly, operations are so complicated that we have to depend upon specialists for the control of each different process." At that time I believe there were 4 paper bottling machines, 2 glass bottling machines, and 4 pasteurizer units operating. Modern devices of this sort are complicated. They must be properly operated to supply people with goods of the quality to which they are entitled. Proper operation requires full and complete understanding of the fundamentals involved in these processes -- another reason for this short course.

At this point, it seems appropriate to discuss briefly the basic organization of the land-grant college in order that there shall be no confusion about the position of the college in this picture. This diagram may help to clarify your ideas on this subject.



For convenience of administration and the development of enthusiasm and knowledge in certain lines of endeavor, the work is broken down into departments. Then the work of the departments falls into three distinct fields -- Teaching (students who come to the college - 4-year courses and short courses), Research (work conducted under the Agricultural Experiment Stations), and Teaching Off the Campus primarily to farm families (through the Federal Cooperative Extension Services whose field representatives you will most readily identify as County Agents. Contact with resident teaching authority and the research specialists is usually through traveling representatives called Extension Specialists.)

Throughout the country, there are very few extension specialists in dairy manufacturing. Here in Oregon, when extension work is needed in dairy manufacturing, the Extension Service sends Dr. Wilster or his colleagues intc the field to service the call. In this particular short course, which is an activity of the teaching program, we will teach you results of the research conducted in the process of vacreation and the sciences related thereto. When teaching a practice applicable to dairy cattle, such as the proper use of a feed nutrient, our extension specialist takesthat information out to the farmers usually through the county agents. The extension dairy specialists in Oregon are H. P. Ewalt and R. W. Morse; in California, G. E. Gordon; in Washington, M. B. Nichols; and in Idaho, E. E. Anderson. In California, Fred Abbott acts as an extension specialist in Dairy Manufacturing. He is the only one we have on the Pacific Coast.

We conceive that it is our function to bring the results of research on the operation of the Vacreator to you sales and service men who will take the same place in the broad picture as our Extension Service does in matters of production. You may, therefore, consider yourselves part of our Extension staff in taking the information to be presented here to the industry as you contact your folks around the territory.

Again, may I emphasize that we are talking about a process -- which we think contributes materially to the development of the dairy industry through the improvement of the quality of dairy products. When we became interested in this Vacreator, Oregon was an exporter of butter (approximately 10 million pounds per year). Since that time, Oregon has lost 50,000 or 60,000 cows and gained one-half million in population. But when we got into this thing in 1938, we were interested in selling butter in California and anywhere else we could find a market. Then, too, we were interested in improving the quality of butter to compete with Canadian butter or New Zealand butter so that, if tariff adjustments occurred, the excellence of Oregon's dairy products would enable them to compete in quality with those of the world. Quite a high ideal -- but then here at the College we believe in high ideals.

When we started our research with the Vacreator, we were told that it was a machine "to make good butter better." We had a cream improvement program in Oregon which had greatly improved the quality of our butter but we had much improvement to effect before our progress would be confined to that which would be made upon sweet cream alone. We were interested in the Vacreator regardless of the desire of its manufacturers to have it used primarily to achieve perfection in the quality of commercial butter made in Oregon. Our experience with the Vacreator demonstrated its ability to cause marked improvement in the quality of butter made from the cream we were then getting at this plant. At that time, the average butter scored about 90 to 91. We were astonished at the improvement made by the Vacreator, never before having the experience of a product or process exceeding the claims made by its advocates to the extent that the process of vacreation exceeded the claims that were made for it.

I still recall the climax to our many surprises when we sent to Eastern Oregon for cream which had been produced from cows grazed on both wild onion and scale weed pastures. We ran that cream through the Vacreator and produced 92 score butter. Butter made from the same non-vacreated cream was inedible. No one believed such a thing was possible. As indicated, this was an extreme case of the effective use of this equipment.

Results of our work with the Vacreator have been published in official Experiment Station bulletins which will be referred to you later. The importance of having this short course is emphasized by the fact that we find some of the men operating the Vacreator who are unable to use it effectively. The expect the impossible from the machine and do not demonstrate good sense in their use of it. One of the jobs we have before us in Oregon is to get more trained men in our manufacturing plants. We are losing ground rapidly in the quality of dairy products in this part of the country because of the lack of suitably trained people to operate our plants. You cannot make a creamery operator out of a truck driver overnight.

A strong reason for welcoming the opportunity to discuss these problems with you is our belief that the supply and equipment people must give better service to the plants until the level of operation can be raised. The situation is alarming. Unfortunately, some of the managers of our manufacturing plants fail to understand what is happening because of the absence of better-trained men in the back room. The boards of directors of cooperative plants need to learn this lesson, too, and some of them could use more training in the front office. Regardless of the quality of the machine you have to work with, you cannot operate it effectively without using common sense. For the time being, at least, it looks like you folks must share with the land-grant colleges some of the education problems necessary to improve our dairy plant operations.

We must have more meetings of this sort if we are going to maintain the level of quality needed here in the Northwest. The quality of butter coming to Oregon is in many cases terrible. The average score, and I say "average," in Oregon must be about 1918 quality. Another thing is that we may have to face the problem of the importation of dairy products. If we do, there is further need for a better job of manufacturing. I am convinced that we must eventually face this fact. The war and the OPA wrecked quality improvement progress made in the dairy industry. To correct this situation is a challenge to you and to me.

You will be shocked when you enter our laboratory to watch the Vacreator in operation. We are passed the shock stage now -- we are used to it and are no longer very sensitive about it. Dr. Wilster has been here 20 years and during that time he and I have planned at least 3 dairy buildings. We are now at the top of the list of new buildings to be built on the Oregon State College campus. A principal phase of this building will be the dairy manufacturing laboratory. We have secured advice from every part of the country concerning the plans for this building. It will be commodious -- so large that when you see it, you will ask why the building was ever planned to be that big! We will be building, however, for expansion. This one has had to serve 50 years and we are planning the new one for the same time. It will be sanitary. The architects are considering every suggestion we make. We are proposing the latest ideas we can get on light, both natural and artificial. When this building is finished and equipped, we will be in a position to give adequate instruction both in the four-year course and in any short course. We can also use it for testing new ideas, processes, and dairy equipment. We lean rather heavily here on the use of improved machinery and equipment. As you will see, we enjoy the close cooperation of our colleagues in the School of Engineering and have always worked in partnership, wherever possible, with our agricultural engineers.

So we hope that when you come again, if you do come to this or some similar type of activity, we will have in another two years an entirely different set-up which will meet every reasonable expectation and satisfy the most rigid ideals."

GENERAL DISCUSSION OF VACREATION

by

G. H. Wilster

Ten years ago (in 1938) the Oregon Agricultural Experiment Station received the following letter from Mr. F. S. Board representing the Murray Company of Auckland, New Zealand.

> "In a practical attempt to introduce the process of "VACREATION" to the butter industry in the United States of America, we have decided to make several small experimental units, (capacity up to 2,500 lbs. cream flow per hour), available for a period in order to test the merits of the process under conditions ruling in your country. It is realized of course, that conditions will vary considerably over so large a territory.
>
> "The process of "VACREATION" combines pasteurization, and steam distillation, in vacuo, in the one machine.
>
> "The investigational work done at the Dairy Research Institute (N.Z.), in connection with the application of this process, was carried out with a machine supplied by my Company, and which we term a VACREATOR. This investigational work was extended to embrace commercial conditions in a number of large factories.

"Certain interim reports on the large amount of work done have been published, copies of two of these reports being annexed, and we understand a comprehensive report is shortly to be issued.

"Meantime we have made rapid strides in the commercial field. In the Auckland Province, where seventy per cent of the Dominion's total butter output is produced, vacreation has become general practice, mainly because feed taints are commonly experienced in this district. Over one hundred butter factories are using vacreation in Australia.

"Vacreation has proved successful in removing clover taint from cream and the resultant butter. Since clover taint is very similar to the taint given to cream by alfalfa, if it is not indeed identical to it, the process may be of particular interest in the Western States, where alfalfa taints are reported to cause much trouble. There is evidence that taints other than those attributed to feed can be removed by vacreation.

"The writer is leaving in June in order to attend to the commissioning of the experimental units in those institutions that may like to undertake investigational work.

"At the suggestion of Professor Wm. Riddet, Chief, Dairy Research Institute (N.Z.), we are writing to inquire whether you would be interested to cooperate in the proposed investigational work, and whether you might care to have one of the small machines on loan for a period for this purpose."

It was known to us that a considerable amount of the milk and cream produced in Oregon commonly had a feed flavor and at times a pronounced weed flavor, the Experiment Station was interested in studying what effect the new process of Vacreation would have on the flavor of the resulting product. The reply by G. H. Wilster to Mr. Board's letter was as follows:

"I thank you for your letter of March 21 in which you are asking us if we would be interested in studying the effect of treating cream in a Vacreator on the quality of the butter.

"There are several sections in our state where difficulty is experienced with feed flavor and weed flavor in the cream received at the creameries. We do know that alfalfa hay when fed in large quantities to cows causes butter that has a distinct flavor although this flavor is not particularly undesirable.

"We are favorable to your proposition and shall be glad to discuss it with you further. We wish to point out, however, that it will be necessary for us to study the method very thoroughly, preferably over at least one year. Furthermore, any results that we may obtain would, of course, be made available to you and also to anyone in our state and elsewhere who are interested.

"I note from your letter that you are planning to leave New Zealand in June for the United States. In the event that you are planning to call on us here, kindly advise me as soon as possible when you expect to make the visit here. My reason for asking you to do this is that I expect to be away from the office in connection with extension work for a number of creameries during part of July and August. Will you also kindly tell me a little more about your proposition so that I can discuss this with Professor P. M. Brandt, Head of the Division of Animal Industries and Dean W. A. Schoenfeld, Dean and Director of the Agricultural Experiment Station."

To this letter, Frank Board replied as follows:

"It is interesting to know that there are sections in the State of Oregon where difficulty is experienced with feed and weed flavors in cream and we are encouraged to learn of your favorable reception of our proposal and that you will be glad to discuss the details with me.

"Broadly the idea is that we shall forward to your Experimental Station a "Baby" machine complete with direct coupled electric water pump and cream pump, at our expense. The equipment to be placed at your disposal for a free trial period of twelve months but to remain our property. You would place the machine in your factory at your own convenience and couple up with power and water at your own expense. (The cost of installation would be very small).

"I would be present to advise in connection with installation and to start up and instruct in operation, and would keep in touch and confer with you in connection with application and experiment from time to time for the first six months at least. It is presumed that apart from delivering the machine at your Experimental Factory there would be no further cost incurred by us in connection with operating, or your experimental work.

"If at the end of the twelve months period you should desire to acquire ownership of the plant and retain same for research and permanent use there should be no great difficulty in coming to terms when the time arrives. (All the State Experimental Stations in Australia have, or are about to install, machines, we meet them liberally with regard to cost).

"We quite understand, of course, that you would retain the right to publish the results of any or all of your experimental work done with the Vacreator, during the twelve months period of trial.

"The machine will handle up to 2,500 lbs. cream per hour. When running it will use from 1,200 to 1,400 gallons of cold water per hour. Steam consumption from 120 to 160 lbs. weight of steam per 1,000 lbs. of cream treated, depending on the quality of the cream. The water pump absorbs from 4 to 5 H.P. and the cream pump 1½ to 2 H.P. Very little floor space is required, about 3 feet x 2 feet.

"I am unable to enclose a photo of the plant but hope to receive some prints from Mr. Lamont Murray quite soon and will then forward.

"I expect to leave Auckland on 14th June but do not yet know whether I shall be landing at Vancouver or San Francisco, but will advise you further of my movements later. It is noted that you will be away from the office quite a lot during the months of July and August, but I will certainly do my best to fit in at your convenience.

"There will, unfortunately, not be time for me to receive a further reply from you before my departure, but you could write further to Mr. Lamont Murray should you think it necessary to reply.

"I hope very much that we shall be able to come to some mutually suitable arrangement, and am looking forward with much interest to being with you, and the useful work we may do together."

This completed the arrangements with reference to obtaining the Vacreator from New Zealand for tests at Oregon State Agricultural Experiment Station. The machine was installed in the Dairy Products Laboratory under Frank Board's supervision during late summer 1938.

About 24 years prior to receiving this communication from New Zealand, G. H. Wilster worked in a condensery in New Zealand where the manager's name was Murray. At that time Murray had no thought of building the Vacreator or ever developing his "dream" process known as Vacreation. It was during the year 1937 that Mr. P. C. H. Petersen of New Zealand, who had formerly employed G. H. Wilster, was visiting in the United States. When discussing developments in New Zealand in recent years he mentioned, among others, that the new type of pasteurizer known as a Vacreator had been invented by H. Lamont Murray, and that he was the man who had operated the condensery at Matangi near Hamilton, Auckland Province, New Zealand. It was a coincidence, therefore, that Frank Board should have picked the Oregon Agricultural Experiment Station as a logical place for the first experimental tests with the Vacreator in the United States. He had never heard that G. H. Wilster had ever worked in New Zealand and if the name was casually brought to Mr. Murray's attention, he probably had forgotten that this man had ever worked for him. After receiving the letter from Frank Board, G. H. Wilster sent the following letter to Mr. Murray:

"I have just received a letter from Mr. F. S. Board with reference to the Vacreator that you are manufacturing. I have advised Mr. Board that we would be very glad to make a test of the process of vacreation of cream provided this test could be made over a period of at least one year, in order that we may study the influence of the process during the various seasons.

"I have heard of your Vacreator through some of my friends in New Zealand and through the literature. Our library here receives a copy once a month of the New Zealand Dairyman. I also learned from Mr. P. C. H. Petersen who was visiting here a year ago on his way to Europe that many Vacreators are now being used in New Zealand and Australia.

"I am wondering if you remember that I worked for you at the New Zealand Packing Company condensed milk factory at Matangi shortly after the factory was built. I trust that I may have the pleasure sometime in the future of meeting you again."

The following interesting reply was received from Mr. Murray, who was at that time, visiting Australia;

"Copies of your letter were sent across to me here where I am on a business visit. Naturally I was most interested to find you are an old friend. I remember you very well indeed and have often wondered what had become of you. Much water has run under the bridge since the old Packing Coy. days and I see you have made good use of the intervening years.

"I am pleased that our mutual friend Petersen has provided a connecting link. Some years ago, I twice visited the United States, staying about four months on each occasion. A number of our early type machines were installed by dairy companies and my introduction to the class of cream they handle was an eye-opened. Aged, stale and semi-putrified, it is impossible to produce high quality butter from it. All that can be done is to arrest its further decay, cleanse it as thoroughly as possible and camouflage it with starter. Unfortunately, I did not have opportunity to inspect the creams and Factory methods employed in the true dairying areas.

"We are, of course, aware that a great deal of butter is made in your country from good cream and it is that section of the Industry that we hope ultimately to interest in Vacreation.

"Realizing the value of institutions such as the one you are associated with, we are hoping to obtain their cooperation in testing the suitability of our method for their local conditions and getting their official pronouncement upon it.

"Today 80% of New Zealand's cream and much of the Australian cream is prepared by Vacreation, such having supplanted the earlier pasteurizing methods, quite definitely to the benefit of the Industry. We are very sanguine of the outcome of American investigation and shall be glad indeed to facilitate that work.

"My colleague, Mr. F. S. Board will shortly be sailing for the United States, taking with him a number of small Vacreator units suitable for research purposes. Mr. Board and I have been closely associated for the past eighteen years in connection with the manufacture of milk products and the evolution and perfecting of improved methods of treatment. Mr. Board received his training in manufacture and marketing firstly in England and possesses a thorough all-round knowledge of the various phases of the Dairying

Industry, both technical and commercial. I am sure you will find a great deal in common.

"He is an excellent fellow personally and as this will be his first visit to the Pacific slope I'm hoping you will be kind enough to acquaint him with the "run of the ropes."

History and Development of Vacreation

The method of Vacreation was developed in New Zealand by H. Lamont Murray, the inventor of the Vacreator, and F. S. Board.

When Murray was operating a condensed milk factory at Matangi in the Waikato district, Auckland Province, New Zealand, he observed that feed flavor, which was common in the milk, was largely eliminated during the condensing process. He later reasoned that if these volatile flavors could be removed from milk while boiling at reduced pressure without any deleterious effect on the natural flavor or other properties of the milk, a similar method might be employed in the treatment of cream used in buttermaking. Flavors in milk and cream arising from turnips, clovers, spring grass and sundry weeds, consumed by the cows, were common. In 1923 Murray and Board while operators of the Te Aroha Dairy Company, Ltd., which had an annual output of 4 to 5 million pounds of butter, set out to apply this principle to the treatment of cream.

The several stages spaced over a period of twelve years, in the evolution of the process of vacreation were:

1. Continuously passing hot flash pasteurized cream through a vessel under vacuum.

2. Introducing steam into the flow of flash pasteurized cream on its way to the vacuum chamber so as to obtain steam- distillation.

3. Elimination of the conventional flash pasteurizer by addition of a direct steam contact section to the vacuum chamber, thus obtaining vacuum pasteurization and steam-distillation in the one unit.

4. The addition of a second and high vacuum chamber wherein to obtain further distillation and cooling.

Present Status of Vacreation in the United States and Other Countries

As of today there are, in the United States and Canada, some 120 Vacreator installations. These Vacreators are being used, collectively, for the vacreation of cream for butter and market cream, ice cream mix, milk for Cheddar cheese and cottage cheese. In Australia and New Zealand, where most creameries have very large butter outputs, it is estimated that from 85 to 90 per cent of all the butter made is from vacreated cream. This would account for about 700 million pounds of the 800 million pounds made annually in these two dominions jointly. There are a number of creameries in New Zealand equipped with two of the large "M" type units while at least one creamery has a battery of three. Some 20 or so plants use Vacreators in the Union of South Africa. Installations are also in operation in Argentina and several European countries. It was recently stated that 80 per cent of all the butter now consumed in Britain, all of which is imported, is made from vacreated cream.

A short time ago Mr. R. H. Trembath, Technologist, Australia Sunny South Service, Melbourne, Australia, visited Oregon. He stated that from 85 to 90 per cent of the over 300 million pounds of butter manufactured in Australia is from Vacreated cream. The cream is produced under high standards. Most of the butter is of excellent quality and nearly one-half of it is exported to Great Britain. Mr. Trembath gave the following reasons for using the process of Vacreation for butter manufacture:

1. To give higher bacterial destruction.
2. To avoid cooked, scorched flavor.
3. To eliminate feed and weed flavor.
4. To improve keeping quality of the butter.
5. To result in a finer flavored butter.

We concur in this.

He stated that the Vacreation method has replaced the vat-holding and the flash method of pasteurization in nearly all the creameries in Australia. The consumption of butter per capita is high in Australia. It was 36 pounds per year prewar, in 1946 it was 25 pounds because of rationing; however, the consumption of ice cream is relatively low, it was only 1.5 imperial gallons per capita per year in 1946.

Results from Research Involving Vacreation of Cream for Butter

The Oregon Agricultural Experiment Station studied the influence of Vacreation on the quality of butter and on the destruction of bacteria in the cream used. A total of 172 churnings was made from 86 lots of first grade and premium grade cream. Eighty-six churnings were made from vat pasteurized cream and 86 were from Vacreated cream. In addition 34 churnings were made from other lots of cream which showed definite defects such as weedy and old cream flavor.

When the vat method of pasteurization was used the cream was heated to 155 degrees F. and held for 30 minutes. For the churnings made from regular first grade and premium cream a temperature of from 190 degrees to 200 degrees F. was used when Vacreating. The butter was graded weekly by a committee of three or four men. Two of these were practical creamery operators. The others were from the Experiment Station staff. The samples were known by number only and the numbering system was such that the judges obtained no clue through the use of even or uneven numbers or of consecutive numbering regarding the method of pasteurization. The results obtained from the experimental work were as follows:

For the 86 comparisons the Vacreated-cream butter scored highest 71 times. The average score of the butter from vacreated cream was 92.38 and the average score of that from the vat-pasteurized cream was 91.55. Thus, vacreation resulted in increasing the average score 0.83 point. This represents a very remarkable improvement when it is considered that the difference in score between mediocre quality butter and the finest commercial butter is only three points, 93 score being the top commercial grade.

The greatest improvement took place during the spring months. This was due, primarily, to the freeing of feed, weed and certain loosely bound extraneous flavors from the cream during vacreation. These flavors masked or obscured the natural flavor of the cream.

Butter in 33 comparisons was shipped in 68-pound boxes to Portland for scoring by the Federal butter grader stationed there and for subsequent sale. Of the butter from vat-pasteurized cream, 10 lots scored 92-93, whereas of the butter from vacreated cream, 25 lots scored 92-93.

When butter in 79 comparisons was stored at a temperature of 0 degrees to 10 degrees F. for four months, there was a difference of 0.78 point in favor of the average score of the butter made from vacreated cream.

The vacreation method was found to be more efficient in killing bacteria than the vat pasteurization method. In 35 comparisons the geometric average number of bacteria per ml. in the vat-pasteurized cream was 9,284 and in the vacreated cream it was 495.

When cream badly tainted with onion, or with French weed, was used in the experiments the vat method was not effective in removing the undesirable flavor, but the vacreation method was effective.

Vacreators for testing purposes were also installed at the University of Manitoba, Winnipeg, Canada, and at the Iowa Agricultural Experiment Station, Ames, Iowa. The tests at Manitoba showed that of 153 direct comparisons made in the study between butter made from vat pasteurized and vacreated cream, all but 8 or 145, were in favor of the butter made from vacreated cream on the basis of the flavor scores. It was found that it was possible to increase the average flavor score of butter made from feed and weed flavored cream 3.35 points. Less improvement was affected when inferior quality stale yeasty metallic creams were used. For average first grade cream the improvement in score due to Vacreation was 1.767.

The tests at the Iowa Agricultural Experiment Station showed that vacreation of good quality cream gave butter of significantly higher score than vat pasteurization of portions of the same cream. There was an average difference of 0.97 point in the score in favor of the butter made from the vacreated cream. Butter made from fine-quality vacreated cream was sent to 10 different state and national butter contests. The scores ranged from 93 to 95 points. Although the cream was vacuum pasteurized at a temperature of 190 degrees to 200 degrees F. in the Vacreator, no undesirable heated or cooked flavor was present in the butter.

Concurrently with the publication of the results obtained with Vacreation of cream for butter at the Oregon Agricultural Experiment Station a report was published by the Dairy Research Institute of New Zealand (The Removal of Undesirable Flavors from Cream used for Butter Manufacture by Riddet, W., Smith, J. W., Beatson, E., and Whitehead, H. R., The New Zealand Journal of Science and Technology, Vol. XXI, No. 5A, 1940). In the introduction to the report it was stated that "the pasteurization of cream for buttermaking in New Zealand has been carried out, until recent years, almost invariably by the use of tandem flash pasteurizers of the Danish type, heating the cream in successive stages to 160 degrees F. to 175 degrees F. and 198 degrees F. to 202 degrees F. This treatment, still used in many factories, is very effective in destroying bacterial life in the cream and hence in improving the keeping-quality of the butter. It does not, however, eliminate to any appreciable extent "feed" and bacterial flavors which may be present in the cream, and these undesirable flavors pass into the butter. Many machines for the removal of flavors have been tried, but the only one of these to gain wide acceptance is the Vacreator, which has been developed during the past ten years by the Mrrray Company of Auckland. The Vacreator has been in use in factories in New Zealand for a number of years and has given such good practical results that it has now displaced flash pasteurizers in all factories in the northern districts.

"It has proved capable of removing most of the "feed" flavor commonly present in cream produced in the northern districts (clover taint) particularly in the spring months, and consequently "vacreation" has become the recognized treatment for "feedy" cream. From time to time, however, doubts have been expressed as to the desirability of subjecting to Vacreator treatment cream free from feed flavors since it has been suggested, inter alia, that the process must necessarily remove not only the undesirable flavors, but also the "natural" cream flavor, thereby leading to the production of butter with a "flat" or "neutral" flavor."

The experiments involved the following:

a. The influence of Vacreator treatment on feed tainted cream.
b. The influence of Vacreator treatment on cream tainted by bacteria products.
c. The influence of Vacreator treatment as compared with flash pasteurizer treatment on sweet cream.

In each case the cream was made into butter and examinations of the butter were made, both fresh and after transport and storage for three months. The temperature of storage was 14 degrees F.

For the tests that involved the vacreation of sour cream that had a definite feed flavor, cream that had an acidity that ranged from 0.33 to 0.53 and averaged 0.46 was used. The official grades of butter made in nine comparisons, before and after storage, and on arrival at London, were as follows: Before storage; After storage; London.

Treatment	Before Storage	After Storage	London
	New Zealand Grading	New Zealand Grading	
Flash	90.3	88.7	89.0
Vacreator	92.3	92.4	92.9
Vacreator plus starter	93.1	93.2	93.0
Maximum Improvement	4.0	2.8	4.0

In addition to the use of feed flavored cream, finest quality sweet cream was also used in the tests.

In the discussion of the results it was stated "an intense treatment in the Vacreator resulted in the production of good first-grade butter instead of the second-grade butter produced from the flash-pasteurized cream. There were, however, constant references in the graders' remarks to flat and insipid flavor in the butter made from the Vacreator-treated cream, indicating that a drastic treatment in the machine tends to remove all flavors. The addition of starter to the Vacreator-treated cream, however, was effective in remedying this defect. The average grade points awarded to the "starter" butter indicate the rather remarkable result that out of the second-grade heavily feed-tainted cream it was possible, with the application of the appropriate treatment, to make finest-grade butter with good-keeping quality.

"The experiments as a whole showed that, although it was not completely effective, the Vacreator was remarkably efficient in removing clover taint and bacterial taints from cream. Furthermore, the machine did not in our experiments have any deleterious effect on finest-quality cream free from taints.

"McDowall has shown that an increased fat loss of about 0.3 per cent of the fat in the cream is to be expected where the Vacreator replaces flash pasteurizers. However, the fact that Vacreator treatment has been adopted in so many factories in New Zealand over the last ten years indicates that increased costs, if they occur, are not prohibitive."

The results obtained from the Vacreation of ice cream mix will be reported later as also will be the results obtained when vacreating milk for cheddar cheese.

Effect on Vitamins

The only report on this subject is by Dr. Rosalind Wulzen, Department of Zoology, Oregon State College, who stated,

"The vacreation process as far as my evidence goes does preserve the anti-stiffness factor in the cream much better than does the ordinary pasteurization. However, I think that this is wrapped up with the destruction of other vitamins, as well, in the ordinary pasteurization method, and one would think first perhaps in making an investigation of the nature of the preservation of vitamin C in the vacreation process hoping that it would be very much greater than in ordinary pasteurization. If such research hasn't been done, that would be my idea of the first line of approach. Any process that would preserve the vitamin C as it is in raw milk would almost without doubt preserve ours also and probably other vitamins as well."

PREAMBLE

by
F. S. Board

When Mr. M. P. Monroe wrote to Prof. P. M. Brandt, requesting the Department of Dairy Husbandry, Oregon State College, to organize a Short Course in Vacreation for the instruction of the Monroe Dairy Machinery Company's staff, he was "making history." Never before, probably, has the "dairy factory equipment" section of the industry requested the agricultural college, in its respective state, to extend the same facilities that are regularly given to the dairy manufacturing groups.

Fortunately we have at Oregon State College men of broad mind, wide vision, and ample courage in the persons of P. M. Brandt, Head of the Department of Dairy Husbandry, and G. H. Wilster, Professor in Dairy Manufacturing. Upon receipt of Mr. Monroe's request for a "Short Course in Vacreation" these gentlemen immediately saw the opportunity thus offered to disseminate experience and knowledge of a process which, if generally adopted, can result in uplifting the quality of dairy products in general and enhancing their nutritional value and appeal. The end point being: more per capita consumption calling for greater production of milk, and the advancement of - (as is generally accepted) the most important branch of agriculture - the Dairy Industry.

And, so, this Short Course was born! Before moving into the subject of my lecture, "The Vacreator and Its Functions," I cannot refrain from making a very modest reference to the zealous and untiring work that has been expended by Dr. Wilster in organizing and preparing the curriculum for this course. Dr. Wilster's untiring energy has been put, whole heartedly, into preparing his lectures, briefing and advising myself and others, and it would be a sad commentary if we - each and all of us - do not derive the utmost benefit from such sincere and high grade instruction. Our appreciation also is due, in no small measure, to those other enthusiastic gentlemen who are giving much of their time and energy in contributing, in large measure, to the curriculum and overall success of this first "Short Course in Vacreation."

THE VACREATOR* AND ITS FUNCTIONS

F. S. Board

*The word VACREATOR is a trade mark and is registered as such in the U. S. Pat. Off., in Canada and other foreign countries. By the dairy industry the word is used to designate a machine wherein milk and other products are pasteurized in reduced pressure or vacuum. Although heating, steam distillation, differential distillation and cooling take place, within the several chambers of the Vacreator, it, nevertheless, is accepted as being a distinct machine with a single entity. Similarly, the several progressive treatments, to which the product is subjected in its rapid transit through the Vacreator, are regarded, collectively, as being a unitary process which is now referred to, generally, by the industry as vacreation.

The Vacreator was invented by H. Lamont Murray in New Zealand where the first machine went into operation, in a commercial butter factory, in 1932. Although, at first, the machine was used exclusively for the pasteurization of cream for buttermaking it is now also extensively employed in the processing of market cream, ice cream mix and milk for cheese.

Pasteurization with the Vacreator is a continuous operation and is classified as a high-temperature-quick-time method. The flow cycle occupies about 10 seconds and only a small amount of product is actually found in the machine at any one moment during operation.

The machine consists, mainly, of three vacuum chambers, a high pressure water actuated ejector-condenser, connecting conduits and a sanitary multi-stage product discharge pump. Manufactured in three sizes, and nominal maximum rated capacities of 3,000, 6,000 and 12,000 pounds cream flow per hour, the unit height and floor space for each type is, respectively: Vac. 3, 6'0" -- 4'6" x 3'2" (exclusive of product discharge pump), Vac. 6, 6'8" -- 4'6" x 3'2" (exclusive of product discharge pump), "M" 7'6" (including concrete base) -- 13'6" x 3'10". The Vacreator is fabricated almost exclusively from stainless steel and the product, in passing through the Vac. 3 and Vac. 6 models, can contact nothing but this metal. The "M" type machine is also of stainless steel except a few of the surfaces which are of tinned bronze. Each machine is equipped with a water pressure gauge, thermometers on the ejector-condenser water inlet and outlet, two vacuum-temperature gauges and a pasteurizing temperature indicating thermometer. Users should equip the Vacreator with a safety thermal limit recorder wired to the product in-feed pump to automatically arrest the forward flow of product to the machine in the event of a falling pasteurizing temperature. Such is called for by several State Regulatory Authorities.

The steam supplied to the Vacreator should be clean, dry, saturated and have no super-heat upon entry. No organic products should be used in boiler water compounds -- such an tannate or lignin -- and the boiler should not be allowed to prime. In the event priming is inevitable the steam line must be adequately trapped as it leaves the boiler. A steam purifier and a steam pressure reducing valve must be mounted on the steam line. There must be a suitable length of uninsulated steam pipe between the steam pressure reducing valve and the Vacreator to insure the dissipation of super-heat.

The steam enters the pasteurizing section, at the side and near the top of the No. 1 chamber, through a regulating valve. Because of the reduced pressure (absolute vacuum) obtaining in this chamber the steam, upon entry, immediately expands and should fall in temperature to a level conforming to the boiling point of water in the pressure that obtains. This pressure (absolute vacuum) is regulated by the operator to give a desired boiling point which is the preferred pasteurizing temperature for the product to be treated. A pasteurizing temperature of 200 degrees F. is generally used, but may be anything between this point and 160 degrees F. should lower temperature processing be required.

The pressure (absolute vacuum) to be carried in the pasteurizing chamber is regulated by means of the equilibrium valve or adjustable throttle. The purpose of this spring tensioned valve is to vary the combined throttling effect of the steam, product, and valve ball in the constricted section at the lower end of the first uptake pipe. By this means the desired vacuum can be accurately maintained at the desired level in the pasteurizing chamber. This temperature control is semi-automatic and very reliable in operation.

The product to be processed enters the pasteurizing section through a special valve which is attached to a port at the side of the No. 1 chamber dome or cover. This valve is held on its seat by a spring, located on the low pressure or vacuum side, which has sufficient tension to hold the valve shut against atmospheric pressure but which opens to admit the product under pressure from the infeed-pump. On the external side there is located an automatic air inlet valve. When the infeed-pump is stopped, and the forward flow of product to the Vacreator is arrested, the external side of the infeed valve is automatically flooded with air. In the event that the seat of the inlet valve should be faulty, product will not be drawn into the Vacreator, only air drawn in from the automatic air valve would enter the machine. The automatic air inlet valve is complementary to the operation of the safety thermal limit recorder and pump stop.

Just below the cover of the pasteurizing section there is located a perforated tray. The incoming product passing through the perforations of this distributing tray is broken up into a shower of small droplets which fall into the expanded steam and pass downwardly with it. Within a split second these product droplets have been elevated to the steam temperature which is the desired pasteurizing point. The mixture of steam and product will have reached the equilibrium valve in something less than two seconds of time. As the steam and product enter the lower pressure region of the first uptake pipe the temperature will immediately drop to a lower boiling point. In the uptake pipe the product will give up gases which will mingle with the steam. In this uptake pipe, and in the upper portion of No. 2 chamber, the product will be subjected to a steam distillation treatment. Such steam distillation treatment is variable as to intensity and temperature. The treatment intensity is measured by the number of BTU passing into the condenser water which increase its temperature. The treatment intensity is, therefore, based on the BTU given up to the condenser by each pound of product. The intelligent use of the steam distillation phase enables the operator to remove extraneous objectionable flavors -- such, for instance, as are derived from feed and weeds -- entirely from the product. The cyclonic effect, that is set up in the No. 2 chamber, and which also obtains in the No. 3 chamber, causes the heavier product to separate from the lighter vapours and gases. While the product spirals to the bottom of the chamber the water vapour and gases are drawn into the vapour pipe and so into the condenser from whence they are ejected with the condenser water.

In the lower part of the No. 2 chamber there is located a float valve. This is known as the intermediate float valve. This valve operates automatically to permit the liquid product to pass out into the second uptake pipe while at the same time holding a seal to prevent interference between the two vacuums or pressure levels obtaining in the chamber and in the uptake pipe respectively. For the second time the boiling point of the product is instantly reduced, causing differential or simple distillation to occur, thus bringing about a considerable reduction in the product temperature. This is because a high vacuum of between 27 and $28\frac{1}{2}$" is maintained in chamber No. 3. The cyclonic effect separating water vapour from the product again occurs, the vapours finding their way into the condenser and the product to the bottom of the chamber and thence to the product discharge pump. The temperature of the product at this point will, generally, be somewhere between 100 and 110 degrees F. The product is delivered by the pump to a cooling means for further cooling.

The vacuum of the No. 2 chamber or steam distillation section is variable and is controlled by means of a snifter valve located on the low vacuum side of the ejector-condenser. The snifter valve is adjusted by the operator to automatically admit air to the low vacuum section of the condenser to prevent the vacuum climbing above some pre-determined point. In general practice the vacuum held in the No. 2 chamber will be somewhere between 15 and 20 inches in order to maintain a steam distillation temperature at some desired point from 160 to 180 degrees F. Should the vacuum in this chamber be depressed to the desired point, by the volume of vapour and gases passing through, the snifter valve should still be set at "the heel of the vacuum" to prevent the vacuum roaming or climbing above the desired point.

If the temperature of the product entering the Vacreator is the same or just a few degrees higher than the temperature of the product leaving the Vacreator there will be neither dilution nor concentration of the finished product. The steam that is condensed into the product in the pasteurizing chamber is removed by distillation in two stages, in the No. 2 and No. 3 chambers, provided that the relationship between the incoming and outgoing temperatures are thus maintained.

The high pressure water is fed to the ejector-condenser by a pump supplied as an auxiliary with the Vacreator. To feed the product to the Vacreator a variable speed positive type pump should always be used, this is very important.

The Vacreator is a comprehensive machine, but is easy to operate once its principles are understood.

HOW VACUUM IS MEASURED

At sea level it takes a column of mercury approximately thirty inches high to counterbalance the pressure of air.

Under vacuum the air pressure is reduced, therefore vacuum is designated by its effect in inches on a column of mercury.

BOILING POINTS AND VAPOUR VOLUMES

Lacteal fluids boil at approximately the same temperatures as water, the actual boiling point being dependent on the pressure. The vapour produced occupies varying volumes, according to pressure.

Approx. Boiling Points		Volume 1 lb. Vapour
Inches of Vacuum	Deg. F.	in Vacuum
0	212 degrees	27 cubic feet
2	208 degrees	29 cubic feet
4	205 degrees	31 cubic feet
6	201 degrees	33 cubic feet
8	197 degrees	36 cubic feet
10	193 degrees	39 cubic feet
12	187 degrees	43 cubic feet
14	182 degrees	48 cubic feet
16	176 degrees	54 cubic feet
18	170 degrees	63 cubic feet
20	162 degrees	75 cubic feet
22	152 degrees	92 cubic feet
24	141 degrees	121 cubic feet
24.5	137 degrees	131 cubic feet
25	134 degrees	143 cubic feet
25.5	130 degrees	158 cubic feet
26	126 degrees	177 cubic feet
26.5	121 degrees	201 cubic feet
27	115 degrees	232 cubic feet
27.5	109 degrees	276 cubic feet
28	101 degrees	339 cubic feet
28.5	92 degrees	444 cubic feet
29	80 degrees	653 cubic feet
29.5	60 degrees	1230 cubic feet
30	32 degrees	3000 cubic feet

THE PROCESS VACREATION

by

G. H. Wilster

Vacreation is a three-stage process of (1) continuous high-temperature pasteurization with direct steam, (2) distillation, with gas and objectionable flavor elimination and (3) partial cooling in enclosed stainless steel chambers under less than atmospheric pressure.

The Vacreator is one of the most ingenious examples of equipment for dairy processing that has ever been invented. It is relatively easy to operate and clean. It can be used for heat treating a number of fluid dairy and food products and it can also be conveniently used for condensing milk and other products and for final dehydration of liquid butterfat. The Vacreator is the most versatile single piece of equipment used today in dairy processing. It is the only known apparatus in the dairy field which combines in a single continuous operation the following:

(a) high-temperature pasteurization under a partial vacuum in the first chamber.

(b) water vapor removal during boiling, in the second chamber, with removal of gasses and objectionable feed and extraneous flavor products.

(c) boiling under high vacuum in the third chamber with further removal of water vapor and extraneous flavors and instantaneous cooling to a temperature about 100 degrees F. below the pasteurization temperature effected by differential distillation.

Description of the process (Slide, flow cycle)

Milk, cream, or ice cream mix, or other fluid dairy products is delivered by the feed pump "X" (see illustration) to the inlet of the tank of the Vacreator and is admitted to the first--pasteurizing--chamber by a float-controlled valve to a perforated spray pan located in the top of the first or pasteurizing chamber "A". It falls in droplets from the spray pan and is heated by direct contact with pure steam admitted through valve "B". The pressure in the pasteurizing section is below atmospheric pressure and may be held at any desired point, usually between 11 inches and 6 inches of vacuum, thus maintaining any temperature from 190 degrees to 200 degrees F. Lower temperatures may also be used as desired, as when pasteurizing milk for cheese. In the bottom of the pasteurizing chamber is located a spring-actuated equilibrium valve "C". The second chamber "E" and the pipe "D" are kept at a reduced pressure of about 15 to 25 inches of mercury by the action of the ejector condenser "F", depending on the product being treated. The relative pressures in "A" and "E" are controlled by the adjustment of the tension on the equilibrium valve "C".

The product on reaching the bottom of the pasteurizing chamber "A" is drawn past the equilibrium valve, passes up the pipe "D" and is discharged tangentially into the cylindrical chamber "E". Under the influence of the lower pressure in the uptake pipe "D" and in chamber "E", the product boils at from 160 degrees to 180 degrees F., and releases as water vapor a portion of its water content to the ejector condenser, the water vapor carrying with it volatile substances present in the product. The intermediate float valve "G" controls the flow of the product through pipe "H" into a third chamber "I", where a still higher vacuum, usually 28 or 28½ inches, is maintained. The product on entering this final chamber loses more water vapor and volatile substances and is instantaneously cooled in the process to about 100 degrees to 110 degrees F. The product is pumped from the bottom of the last chamber to the cooler by a multistage centrifugal pump "Y".

The amount of steam passing through valve "B" is in excess of that necessary to raise the temperature of the product to the pasteurizing temperature. This excess of steam aids in the freeing and carrying away of certain volatile substances from the product, such as may be imparted by feed and weeds. The rise in temperature of the cold water, forced through the ejector-condenser by pump "Z", is an indication of the amount of heat (B.T.U.) drawn off from the hot product in the reduced-pressure chambers.

It should be emphasized that pasteurization takes place in the first chamber between the point where the product is mixed with the steam and the equilibrium valve. About 3/4-pound cream of ice cream mix per second is pasteurized in the chamber with the small-sized Baby machine. The indicating thermometer and the recording thermometer bulbs are inserted in the bottom part of the chamber <u>before the product passes the equilibrium valve</u>. On account of the reduced pressure obtaining in the chamber boiling takes place. By boiling is understood the ebullition or bubbling agitation of a liquid with the giving off of water vapor. The boiling point is defined as the temperature at which the bubbling agitation of the liquid begins. This takes place at different temperatures depending on the pressure of the liquid. Water boils at a temperature of 212 degrees F. at sea level pressure (14.696 pounds absolute per square inch.). When the pressure is increased as in a steam boiler it boils at a higher temperature (at 100 pounds per square inch gauge pressure or 114.696 (115) pounds absolute the boiling point is 338 degrees F.).

In another lecture will be discussed the factors in the field of physics that relate to vacreation.

The following table shows the relation of pressure per square inch and inches of vacuum as measured by the vacuum gauge to the boiling temperature. The common temperatures in the Vacreator when vacreating sweet cream for butter are indicated.

RELATION OF PRESSURE TO THE BOILING POINT OF WATER

Boiling Points of Water at Different Partial Vacuums

Pounds per sq. in.	Vacuum gauge Inches	Boiling Point Degrees F.		Pounds per sq. in.	Vacuum gauge Inches	Boiling point Degrees F.	
14.7 ------	0	212.0			23.5	143.4	
	1	210.2			24.0	140.4	
	2	208.6			24.5	136.9	
	3	207.0		2 ------	25.0	133.2	
	4	204.8			25.5	129.2	
12 ------	5	203.0			26.0	124.7	
	6	201.0)			26.5	119.7	
	7	198.9)	1st		27.0	114.1	
	8	196.7)			27.5	107.6	3rd
	9	194.5		0 ------	28.0	99.9	------
9 ------	10	192.2			28.1	89.1	
	11	189.7			28.2	96.3	
	12	187.2			28.3	94.3	
	13	184.6			28.4	92.1	
	14	181.8		0 ------	28.5	90.0	
7 ------	15	178.9			28.6	87.6	
	16	175.8			28.7	85.3	
	17	172.6			28.8	82.6	
	18	169.0)			28.9	80.4	
	19	165.2)		0 ------	29.0	76.6	
4 ------	20	161.2)			29.1	73.2	
			2nd				
	20.5	159.1)			29.2	69.3	
	21.0	156.7)			29.3	64.9	
	21.5	154.4		0 ------	29.4	59.9	
	22.0	151.9			29.5	54.1	
	22.5	149.2		0 ------	29.6	46.9	
3 ------	23.0	147.2		0 ------	29.7	37.0	

Zero inch mercury on vacuum gauge = 760 mm. mercury column or 14.7 pounds per square inch absolute.
29.92 inches mercury on vacuum gauge = zero mm. mercury column or total vacuum.

Efficiency of the Vacreator

It can be stated, based on ten years' experience in vacreating different dairy products at Oregon State College, that the Vacreator is an efficient pasteurizer. Vacreation is not, however, a method for making first-grade cream from second or third-grade cream. To be sure improvement in flavor will take place when the cream is vacreated, but when once contaminated and possessing an objectionable flavor, there is no known method of processing that can restore the product to its original high purity and excellence. Inferior quality milk and cream should be returned to its place of origin and should not be used in the manufacture of dairy products.

The Vacreator is an efficient pasteurizer. The research conducted with churning cream at Oregon State College during 1938 to 1940 showed this. In 35 comparisons the raw cream had a geometric average content of bacteria of 49,000,000 per ml., the vat pasteurized cream had a geometric average of 9,284 bacteria per ml., and the vacreated cream had a geometric average of 495 bacteria per ml. The average percentage of the bacteria killed was 99.981 for the vat method and 99.999 for the vacreation method. While the difference in the percentage killed by the two methods of pasteurization is small the uniformly better efficiency obtained with the vacreation method is significant. It nearly reached perfection. All yeasts and molds were destroyed.

In elaborating further on vacreation we can state that:

Moist heat in the form of steam is used in one chamber for heating the product.

No hot metallic heating wall is used.

Oxygen is largely, if not completely, eliminated.

If saturated steam is used there will be no scorching of the product.

Gravity feed or positive feed may be used as desired.

There are no moving parts of the machine proper.

Both differential distillation and steam distillation* takes place. The vapors which arise from and are added to the boiling cream or milk product, at low temperature, carry volatile feed and other extraneous flavors to the condenser water.

There is accurate temperature control with automatic minimum temperature control if desired.

There are no stuffing boxes in the machine proper.

There is removal of carbon dioxide from the cream.

There is cooling - a total of 100 degrees F. - in the machine without the use of any cooling surface and this takes place in the absence of oxygen without exposure to light.

The operation is continuous and practically automatic.

Phosphatase is destroyed.

There is a high bacterial killing efficiency.

Yeasts and molds are totally destroyed.

The machine is easy to clean.

The machine is easy to operate provided it is properly assembled and properly cared for.

The machine is flexible.

A record of the temperature treatment in the pasteurizing chamber can be made.

The complete apparatus can be steam sterilized before it is used.

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* Distillation = The process of vaporizing a liquid and condensing the vapors by cooling.

Differential Distillation = (simple distillation). Distillation where vapor generated by a boiling liquid is withdrawn and condensed as quickly as it is formed.

Steam Distillation = Distillation process where steam is passed through a heated liquid. The steam carries away materials by forming volatile mixtures having a lower boiling point than the material itself.

Approval of Vacreation

The Oregon State Department of Agriculture has officially approved the process when used for churning cream and when used for ice cream mix. Members of the Department observed the operation of the Vacreator in the Dairy Products Laboratory at Oregon State College, and under date of December 31, 1947 Mr. Kenneth E. Carl, Assistant Chief, Division of Foods and Dairies, Oregon State Department of Agriculture, advised Mr. F. S. Board that, "The demonstration proved to the satisfaction of the department that the process of vacreation is an efficient means of pasteurizing churning cream and ice cream mix provided that:

"1. The Vacreator is equipped with a safety thermal limit recorder controller, and

"2. Wired to an automatic pump stop whereby the forward flow of raw cream or mix to the Vacreator automatically stops when the temperature in the pasteurizing chamber drops below 190 degrees F. as indicated on the recorder controller, the bulb of which is located at the bottom of the pasteurizing chamber.

"The sensitivity, speed and positive action of the cut-out and cut-in response of the thermal limit safety recorder and milk pump stop is entirely satisfactory as used in conjunction with the Vacreator as controls for pasteurizing temperature and time requirements.

"For the time being the Department will restrict the use of the Vacreator as a means of pasteurization to milk products wherein the pasteurizing temperature shall not be less than 190 degrees F. As for such milk products as cheese, where pasteurizing temperatures below 190 degrees F. are required, there is need for more data on what these minimum temperatures should be for pasteurizing milk used for manufacture of such dairy products. The Department will look to Dr. Wilster to advise on this matter when the college has compiled sufficient data to arrive at recommendations concerning the temperatures and controls required for satisfactory pasteurizing and quality results."

Vacreation a Unitary Process

Vacreation is more than the summation of the separate results obtained in each of the three chambers. It is a unitary combination of the treatments. Lamont Murray desired to develop a machine having a specific entity, not just an aggregation of pasteurizer, distilling apparatus, and cooler. It took many years of painstaking work to develop a machine that would combine the steps in the vacreation process in one unit. The Vacreator has emerged as a complete unit to efficiently treat milk and cream, to give distinct complementary treatment to the products. The treatments combine to result in what is known as "vacreation."

Suppose we take the Vacreator apart and try to operate each unit separately.

1. In the pasteurizing chamber steam would be mixed with cream to increase the temperature to about 200 degrees F. The steam used would be condensed in the cream and the product would be diluted with about 10 to 12 percent water. The cream would then have to be cooled by a cooler to 100 degrees F. in order to equal the cooling that takes place instantaneously in the Vacreator. There would be no removal of gasses or volatile substances.

2. In the second chamber water vapor and volatile substances are removed. The temperature, because of the lower vacuum, is reduced about 30 degrees F. Such a chamber, if operated independently of the other two would be connected to an ejector-condenser. It would be provided with an automatic infeed control, it would have steam connected at the inlet, and a dis-

charge pump would be provided at the outlet. The milk, cream, or ice cream mix would first be pasteurized by any standard atmospheric means at from 190 degrees to 200 degrees F. and would be fed into the steam distillation chamber at this temperature. A vacuum of from 15 inches to 20 inches would be maintained, and steam would be added at the inlet in such quantities as to maintain normal steam distillation intensity. The milk or cream issuing from the machine at 160 degrees to 180 degrees F. would be cooled within a standard type of cooler.

3. Now if the third or high-vacuum chamber in which instantaneous cooling to the extent of about 50 to 60 degrees Fahrenheit takes place by removal of heat by distillation, here we would have a high vacuum chamber standing alone, connected to an ejector condenser and fitted with automatic inlet feeds and a discharge pump at the outlet. The milk, cream, or ice cream mix would be pasteurized preliminary as was the case with the second treatment, but it would then be cooled atmospherically to 160 degrees to 180 degrees F. before it was introduced into the high vacuum chamber. The vacuum must be maintained at 27 to 28 inches so that the product would leave the chamber at about 100 degrees F. for further cooling by means of an outside cooler.

Instead of all this complicated treatment we now have a single unit, compact and easy to operate for (1) pasteurizing, (2) removing feed flavor, and (3) cooling the product to 100 degrees below the pasteurization temperature. The process is almost instantaneous.

How the Vacreation Process may be Varied

To fully understand the process "vacreation" let us discuss what happens when we manipulate the control devices one at a time when the Vacreator is being operated as follows:

2300 pounds cream passing through the machine per hour.

1st vacuum chamber	6" vacuum	201 degrees F.
2nd vacuum chamber	20" vacuum	161 degrees F.
3rd vacuum chamber	28" vacuum	100 degrees F.

Water to condenser, 50 degrees F., 60 per square inch pressure equal to 9,400 pounds per hour.

Vacreator in good condition and is correctly assembled.

FACTORS.	RESULT
1. Increase in flow of cream.	It is assumed that there is always much more steam flowing into the Vacreator than is required to heat the product to the pasteurizing temperature. Therefore, if the flow of cream is increased, the result will be a greater throttling* at the equilibrium valve followed by a slight reduction of the vacuum in the pasteurizing chamber. This, in turn, may be offset by the condensing of more of the steam by the additional incoming cream. The pasteurizing temperature may not be changed or it may be affected slightly and show either a slight rise or fall. The temperature of the outgoing water would drop if more of the steam heat was retained in the outgoing cream or it could rise if the temperature of the incoming cream is higher than the cream temperature as it leaves the Vacreator. *Throttling - checking, choking, obstruction.
2. Decrease in flow of cream.	If the flow of cream is decreased there will be less throttling at the equilibrium valve and a slight increase of the vacuum in the first chamber. The pasteurizing temperature may be affected slightly; it may increase.
3. Decrease in the amount of steam to first chamber.	Pasteurizing temperature may or may not be affected. (Vacuum in pasteurizer would increase slightly thus slightly reducing the pasteurizing temperature.)

		Outgoing water temperature would drop.
4.	Increase in steam to first chamber.	Pasteurizing temperature may or may not be affected. (Vacuum in pasteurizer would fall slightly followed by slight increase in pasteurizing temperature.) Outgoing water temperature would increase.
5.	Decrease in the flow of water to condenser.	Increase in outgoing water temperature. Possible loss of vacuum and higher temperature of product leaving the Vacreator.
6.	Increase in flow of water to condenser.	Decrease in outgoing water temperature. Some increase in vacuum with lower product temperature leaving the machine.
7.	Increase in tension on equilibrium valve by turning wheel to the right thus closing down the ball in its socket.	Increase in pasteurizing temperature by decreasing vacuum in the first chamber.
8.	Decrease in tension of the equilibrium valve by turning the wheel to the left thus allowing more space between ball and socket.	Decrease in pasteurizing temperature by increasing vacuum in the first chamber.
9.	Reduce tension completely on equilibrium valve.	Decrease in pasteurizing temperature by increasing vacuum in the first chamber.
10.	Remove the ball in equilibrium valve.	Further decrease in pasteurizing temperature but the first and second chambers do not quite equalize because of the throttling effect of the product - steam and cream mixture - passing through the equilibrium valve orifice.
11.	Run snifter valve in.	Admits more air to second chamber thus decreasing the vacuum and increasing the temperature. The vacuum in the first chamber would also be decreased with an automatic rise in temperature.
12.	Run snifter valve out.	Admits less air to second chamber, in-

	creases the vacuum and decreases the temperature in the second chamber. Also increases vacuum in first chamber and decreases pasteurizing temperature.
13. Reduce vacuum in second chamber.	Increases temperature in second chamber. Also increases pasteurizing temperature in first chamber.
14. Increase vacuum in second chamber.	Decreases temperature in second chamber. Also decreases pasteurizing temperature in first chamber.
15. Increase temperature of condenser water without increasing volume of water.	Use more steam. If the amount of steam then being used is excessive some entrainment might occur, (not through boiling).
16. Excessive boiling and entrainment - what should be done.	Any boiling of the product, leading to entrainment, is due to sudden increase of vacuum in either or both the #2 and #3 chambers. A sudden climb in vacuum in #2 chamber cannot occur if the snifter valve is set "on the heel of the vacuum." Therefore, when boiling arises in this chamber, because of a roaming vacuum, the snifter valve setting needs adjusting. A sudden climb in vacuum in #3 chamber will occur when starting up if the intermediate float valve is not holding tight (needs grinding). It will also happen at time of shutting down just when the load is taken off. There is no provision for overcoming this in present machines. There should always be a trickle of water flowing through the jackets to take the product off the simmering stage.
17. Treatment intensity - how to increase.	(a) Add more steam. (b) Reduce rate of flow of the product to the machine. Treatment intensity - Number of B.T.U. passing into condenser water per unit of product being treated.
18. To decrease treatment intensity - what should be done.	(a) Use less steam. (b) Increase rate of flow of the product to the machine.

What is Understood by "Treatment Intensity?"

Murray so designed the Vacreator that it is possible to treat the milk or milk product at different degrees of intensity. This is one of the outstanding advantages of vacreation. This is a very remarkable invention.

The pasteurizing temperature in the first chamber is best maintained at 190 degrees to 200 degrees F. Although efficient pasteurization occurs at temperatures as low as 190 degrees F. the higher temperatures insure a greater pasteurizing efficiency.

The vacuum in the second chamber should not be higher than 20 or 21 inches and not lower than 15 inches. As the grade of cream is lowered (either due to feed and weed flavor or otherwise) so must the temperature in the second chamber be higher and the vacuum carried lower.

Treatment intensity means that the amount of steam admitted to the Vacreator over and above that necessary for pasteurization can and should be adjusted as deemed sufficient on the basis of the intensity of the feed or weed flavor in the milk or milk products. The steam control valve used together with the ingenious but simple control system known as the equilibrium valve (it was not so easy to devise) enables the operator to increase or decrease the degree of steam distillation. For sweet cream having little feed flavor a mild intensity treatment is given, and with strong feed or weed flavored milk or cream a stronger treatment is given.

The vacuum in the final chamber should always be dept as high as possible. This is extremely important. It means a greater elimination of odors, reduction of dilution, improvement in flavor, and more cooling.

To increase the intensity of treatment, increase the steam and/or reduce the flow of product. To increase the treatment temperature reduce the vacuum. The boiling point is thus increased. The vacuum could be reduced to 15 inches in the second chamber but not lower. The lower vacuum is obtained by running in the snifter valve admitting more air. The boiling point of water at this pressure is 179 degrees F.

If more or less steam is used per unit of product the treatment-intensity is either increased or decreased. If more or less product is fed to the machine while the steam flow remains constant, the treatment-intensity is thereby changed. The treatment-intensity is measured by the total weight of water vapor that leaves the product and passes into the condenser.

To decrease the intensity use less steam or treat more product.

The rise in temperature of the water passing through the condenser is an indication of the amount of water vapor drawn off from the hot cream in the vacuum chambers. From the rise in temperature of the condenser water and the flow of water through the condenser and the rate of flow of product it is possible to derive a figure which expresses the intensity of treatment of the cream. This figure is known as the "treatment intensity figure."

The temperature rise of the condenser water must never be less than the safe minimum expressed by the following equation:

$$\frac{\text{Pounds product per hour} \times \text{Difference between pasteurizing temperature and cream discharge temperature}}{\text{Pounds condenser water per hour}} + 10$$

Example:

2300 pounds cream per hour

Pasteurizing temperature 200 degrees F.

Cream leaving Vacreator at 105 degrees F.

10,000 pounds condensing water per hour

$$\frac{2300 \times (200 - 100)}{10{,}000} + 10$$

$$= \frac{2300 \times 100}{10{,}000} + 10$$

$$= \frac{230,000}{10,000} + 10$$

$$= 23 + 10 = 33$$

The figure 33 represents the safe minimum rise in the condenser water. By "safe" is meant that there is not less than sufficient steam flowing into the machine to lift the product to the desired pasteurizing temperature. The machine is not "starved" for steam for pasteurization.

The addition of the figure 10 to the results simply ensures that a safe margin, over and above the theoretical amount, of steam shall be available. Plus 5 might be a safe figure to allow for radiational loss, etc.

It must be understood that the figure 33 represents only the safe minimum rise and not necessarily the optimum rise to use. A rise of at least 40 degrees Fahrenheit in the condenser water is recommended in treating even the finest quality cream. More than 40 degrees rises are recommended for cream or milk having strong weed or feed flavors.

The intensity index is the temperature rise occurring in the condenser water when weight of water and flow of product are taken into consideration.

To determine the intensity figure at which the machine is operating use the following formula.

$$\frac{\text{Pounds condenser water per hour x temperature rise of water}}{\text{Pounds cream flow per hour}} = \text{intensity figure}$$

For instance to determine the intensity figure in the above problem by substituting in the formula we have 10,000 x 33 ÷ 2300 = 143. The intensity figure is 143.

Conversely to find the temperature rise needed to produce a certain intensity figure the following formula should be used.

$$\frac{\text{Pounds cream flow per hour x Intensity figure}}{\text{Pounds condenser water per hour}} = \text{Temperature rise required}$$

Example, to find the minimum temperature rise required in the above problem when given the intensity figure by substituting in the above formula we have: $\frac{2300 \times 143}{10,000} = 32.9$

The figure 32.9 (or 33) means the minimum temperature rise in the condenser water required.

Because the intensity treatment received by the product varies with several factors, some of which are controllable by the operator, and because different types and qualities of product require different intensities of treatment, the importance of determining and using the correct intensity of treatment can be easily seen.

When treating weedy flavored cream the intensity figure might be:

$$\frac{10,000 \times 70}{2300} = 304$$

An intensity of 304 should be used.

Let us assume that onion-flavored cream must be vacreated, using a pasteurizing temperature of 200 degrees F. and having 200 pounds cream passing through the Vacreator per hour.

Vacuum in second chamber is 18 inches (boiling point 170 degrees F.). Difference in temperature of ingoing and outgoing condenser water is 50 degrees F. 10,000 pounds water per hour used.

$$\text{Intensity treatment} = \frac{10,000 \times 50}{2,000} = 250$$

If the onion flavor is not quite removed the intensity treatment should be increased. To do this (1) reduce inflow of cream or (2) increase outgoing water temperature without causing entrainment.

It is desired to try (2) first. Therefore, (a) Run snifter in to decrease vacuum in second chamber to 15 inches, (b) Increase tension on equilibrium valve to raise ball in socket, thereby lowering vacuum in pasteurizing chamber, and (c) Admit more steam to maintain a temperature of 200 degrees F.

(If the adjustment was made in the equilibrium valve only, no additional heat units would enter the Vacreator and the temperature of the outgoing water would not change materially.)

It was stated above that the intensity treatment could be increased by reducing the rate of flow of product going through the Vacreator.

Example: Rate of inflow 1500 pounds per hour

Vacuum in second chamber 18 inches

(boiling point of wwater 170 degrees F.)

Difference between temperature of ingoing and outgoing condenser wàter 50 degrees F.

10,000 pounds water per hour

$$\text{Intensity treatment} = \frac{10{,}000 \times 50}{1{,}500} = 333$$

RELATION OF PRESSURE TO THE BOILING POINT OF WATER

Vacuum Gauge	Boiling Point Water	Pounds Pressure	Vacuum Gauge	Boiling Point Water	Pounds Pressure
Inches	Deg. F.	per sq. in.	Inches	Deg. F.	per sq. in.
0	212.0	14.696	22.5	149.2	3.396
1	210.2	14.206	23	147.2	3.396
2	208.6	13.716	23.5	143.4	3.156
3	207.0	13.226	24	140.4	2.906
4	204.8	12.736	24.5	136.9	2.666
5	203.0	12.236	25	133.2	2.416
6	201.0	11.746	25.5	129.2	2.176
7	198.9	11.256	26	124.7	1.926
8	196.7	10.766	26.5	119.7	1.676
9	194.5	10.276	27	114.1	1.436
10	192.2	9.786	27.5	107.6	1.186
11	189.7	9.296	28	99.9	0.946
12	187.2	8.806	28.2	96.1	0.846
13	184.6	8.316	28.4	92.1	0.746
14	181.8	7.816	28.6	87.8	0.646
15	178.9	7.326	28.8	82.6	0.556
16	175.8	6.836	29.0	76.5	0.456
17	172.6	6.346	29.1	73.2	0.406
18	169.0	5.856	29.2	69.3	0.356
19	165.2	5.366	29.3	64.9	0.306
20	161.2	4.876	29.4	59.9	0.256
20.5	159.1	4.626	29.5	54.1	0.206
21	156.7	4.386	29.6	46.9	0.156
21.5	154.4	4.136	29.7	37.0	0.106
22	151.9	3.886	29.74	32.0	0.086

Perfect vacuum = 29.921 inches of vacuum
= 14.696 lb. per sq. inch reduction in pressure

To convert inches of vacuum to pounds pressure use formula.

$$\text{Pounds per square inch} = \frac{14.696 \times (29.921 - \text{In. vacuum})}{29.921}$$

PASTEURIZATION: EFFECT ON BACTERIA, YEASTS, MOLDS, AND ENZYMES

by

P. R. Elliker

The story of the development of pasteurization practically parallels that of the early development of the science of bacteriology. It is indeed proper that the process of pasteurization is named after Louis Pasteur, its originator, who frequently has been referred to as the "father of modern bacteriology."

Fortunately, from the standpoint of food preservation, vegetative cells of bacteria (those cells without spores) are relatively susceptible to exposure to high temperature. Vegetative cells of most bacteria are destroyed at a temperature of 140 degrees F. in ten minutes or less. The spores of spore-forming species of bacteria, on the other hand, are far more resistant to heat and some may survive boiling in water for more than 24 hours. The fact that vegetative cells are responsible for most spoilage of food led to the application of heat treatment to destroy most of the vegetative cells and thus preserve the food for limited periods.

Pasteur was the first to recognize the possibility of a mild heat treatment for this purpose. During the period of 1860 to 1864 he was studying spoilage of wine and found that a few minutes heating at 122 degrees to 140 degrees F. was sufficient to prevent growth of undesirable bacteria causing defects such as bitterness, souring, and ropiness in wine. A few years later he applied the same principle to beer and was able to prevent undesirable souring and other defects. The process later was appropriately termed pasteurization. The first commercially pasteurized milk was reported in Germany in 1880 and a short time later in Denmark and Sweden. In 1888, cream for buttermaking was pasteurized in Denmark and in 1898 the practice became compulsory. In 1897 H. E. Schuknecht introduced the practice of pasteurizing cream for buttermaking in this country at Albert Lea, Minnesota and the practice grew until now it is employed by practically all commercial creameries in this country.

Considerable variation in the methods of carrying out such a fundamental process as pasteurization is to be expected. Consequently today a number of methods of pasteurizing milk, milk products, and other foods are recognized. The most important in the dairy industry are: (1) The vat or holder method where the product is heated for a relatively long period of, for example, from 30 to 60 minutes at the required temperatures; (2) the flash method where the product is heated momentarily at a temperature of about 180 degrees F. or higher; (3) the steam injection method where the product is heated momentarily by direct steam injection to a temperature of 180 to 200 degrees F. or higher; (4) high temperature short time method, sometimes known as the high short or short time method; it involves rapid heating of the product to 160 degrees F. or higher for 15 seconds or more. Stassanization resembles the short time method in principle; (5) vacreation which involves application of a vacuum and steam simultaneously to combine pasteurization, removal of undesirable odors and flavors, and cooling.

The common objectives of these various treatments are: (1) the destruction of all disease-producing bacteria that might be present, and (2) improvement of the keeping quality of the product by elimination of bacteria, yeasts, molds, and enzymes that might cause subsequent spoilage therein.

Where it has been carried out properly, pasteurization has been overwhelmingly successful in accomplishing the above objectives and as such has represented one of the most valuable single contributions to the modern food industry. Only in occasional instances does it represent a serious disadvantage. One such is the difficulty of producing a typical ripened or cured flavor in certain cheeses made from pasteurized milk. Even in the case of such cheeses as Cheddar, however, the benefits due to the destruction of disease-producing and undesirable spoilage bacteria in general outweigh the disadvantages, and the trend is steadily toward pasteurization of all cheese milk. Milk and a number of milk products, since they represent an ideal culture medium for microorganisms, could present an imposing public health hazard. The most important single reason for the relatively few disease outbreaks traced to milk and milk products in recent years is the almost universal practice of pasteurization in the dairy industry.

Time-Temperature Relationships Required for Bacterial Destruction

This discussion will of necessity deal with the general subject of pasteurization although it is realized that the problems for cream or ice cream mix for example are different from those of milk pasteurization. Different methods of pasteurization necessitate some common denominator for estimating bacterial destruction. According to a League of Nations' Report (1) the following temperatures and times represent equivalent exposures from the standpoint of bacterial destruction in milk: 140 degrees F. for 60 minutes, 143.6 degrees F. for 25 minutes, 150.8 degrees F. for 4 minutes, 161.6 degrees F. for 15 seconds, 168.8 degrees F. for 2.4 seconds, 176 degrees F. for 0.4 seconds, and 185 degrees F. for 0.04 seconds.

At present the pasteurization standards for market milk are the most rigidly enforced. Market milk must be pasteurized at 143 degrees F. for 30 minutes, or 100 degrees F. for 15 seconds (usually 161 degrees for 16 seconds) to render it phosphatase negative. It cannot be overpasteurized without affecting its creaming ability. Homogenized milk with no cream line problem frequently is purposely overpasteurized as is also the case with chocolate milk.

The results of Dahlberg and associates (2) suggest that there still may be improvements possible in the times and temperatures employed for pasteurization of market milk. They pasteurized milk successfully at temperatures of 169 degrees to 177.5 degrees F. with controlled heating and cooling periods above 140 degrees but without holding at the highest temperature attained. For example, when milk was heated to 170 degrees F. the time interval required for raising the temperature from 140 degrees to 170 degrees F. and cooling back below 140 degrees F. was 12 seconds. This process was termed "Quick Time Pasteurization." It resulted in bacterial and phosphatase destruction equivalent to vat pasteurization at 144 degrees F. for 30 minutes and appeared to provide a greater margin between the temperatures that produced impairment of the creaming properties of milk and gave milk with a negative phosphatase reaction than was true at lower temperatures.

According to Hunziker (3), the minimum approved standard for pasteurizing cream for butter manufacture by the holder method is 145 degrees F. for 30 minutes. However, many creameries pasteurize at 160 degrees to 170 degrees F. for 30 minutes. Wilster(4) has recommended the following exposures for pasteurization of cream by the vat method: High acid, neutralized cream, 155 degrees F. for 30 minutes; medium acid, neutralized cream, 158 degrees F. for 30 minutes; sweet cream, 160 degrees F. for 30 minutes. Many creameries pasteurize at 160 to 170 degrees F. for 30 minutes. The standards for high temperature pasteurization of cream are less definite. Hunziker (3) states that the temperature should be 180 to 185 degrees F. or above for momentary exposure. Higher temperatures of 190 degrees to 200 degrees F. are commonly used. In the case of ice cream mix the U. S. Public Health Service Frozen Desserts Ordinance and Code (5) specified 155 degrees F. for 30 minutes as the minimum approved exposure by the holder method. A temperature of 160 degrees F. for 30 minutes commonly is used for vat pasteurization of ice cream mix. Dowd and Anderson(6) found pasteurization at 180 degrees F. for 19 seconds by the high temperature short time method to be equivalent to 160 degrees F. for 30 minutes in reducing the total bacterial count of ice cream mix. Results of these and other studies cited by Minthorn suggest that a requirement of 175 degrees F. for 25 seconds may represent a reasonable standard for pasteurization of ice cream mix.[1] Wilster (7) employed a temperature of 198 degrees F. in vacreating ice cream mix.

The above exposures indicate first of all that some effort should be made toward standardization of high temperature pasteurization of products other than milk and second that products such as cream and ice cream mix require a greater exposure to heat for bacterial destruction than do whole milk or skimmilk. Further studies are needed to establish the rates of bacterial destruction at different temperatures in milk and milk products. The above-mentioned conclusions of Dowd and Anderson emphasize the increased resistance shown by bacteria in ice cream mix as compared with milk. Speck (8) in his studies with a heat resistant organism, Micrococcus freudenreichii, concluded that the time required for 99.99 percent destruction at a given temperature was two to four times as long in ice cream mix as in whole milk. Paley and Isaacs (9) have ateempted to determine the reason for the protective effect of ice cream mix by determining the exposures required to destroy cells of a 24-hour culture of Escherichia coli. When approximately one million per ml. of cells were inoculated into milk and ice cream mix and these then heated at 143 degrees F., all were destroyed in the milk in 20 minutes and a number of cells survived 35 minutes in the ice cream mix. They determined the effect of addition of separate ingredients to milk on heat resistance of the organisms. Butter, flavor, gelatin, sugar, and color exerted no effect but sodium alginate and locust bean gum exerted a protective effect. Studies on foods other than ice cream have shown sugars to exert a protective effect on microorganisms during exposure to high temperatures. Nelson (10) found that 150 degrees F. for 30 minutes was necessary to destroy phosphatase in ice cream mix.

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[1] C. M. Minthorn, "Short Time High Temperature Pasteurization of Ice Cream Mixes." Paper presented at Annual Convention of the International Association of Ice Cream Manufacturers, Atlantic City, October, 1948.

Effect of Pasteurization of Various Microorganisms in Milk and Milk Products.

It should be kept in mind in discussing the effect of pasteurization on microorganisms and enzymes that the excessive exposures commonly employed for cream and ice cream mix frequently result in greater bacterial destruction than occurs in pasteurization of market milk. Since most reports have been concerned with destruction of bacteria in milk this discussion will be limited chiefly to effect of pasteurization on microorganisms in milk.

Disease-Producing Bacteria. The most important human diseases from the standpoint of their transmission through milk and milk products are: (1) tuberculosis caused by the bovine strain of Mycobacterium tuberculosis, (2) brucellosis or undulant fever caused by Brucella mellitensis, Brucella abortus, and Brucella suis, (3) septic sore throat and scarlet fever caused by Streptococcus pyogenes, (4) diphtheria caused by Corynebacterium diphtheriae, (5) typhoid fever caused by Salmonella typhosa, (6) food poisoning due to both Micrococcus pyogenes sureus and albus. A number of other diseases of lesser importance include paratyphoid fever, dysentery, and diarrhea.

Approved pasteurization procedures unquestionably destroy all of the above-mentioned bacteria that may be present in the product. The toxins of M. aureus and M. albus survive pasteurization, but the bacteria producing the toxins are destroyed. The significance of this fact will be discussed later. The most resistant of the pathogenic bacterial species mentioned is Mycobacterium tuberculosis. Consequently present pasteurization exposures are based chiefly on our knowledge of the heat resistance of M. tuberculosis in milk. Theobald Smith (11) laid the foundations for present day pasteurization exposures when he found that M. tuberculosis in milk was destroyed in 15 minutes at 140 degrees F. if no pellicle was present, but if a pellicle was present, it might survive 140 degrees F. for 60 minutes. Russell and Hastings (12) showed that it could be destroyed in a tightly closed container at 140 degrees F. in 10 minutes. Rosenau (13) showed that it was destroyed in 20 minutes at 140 degrees F. and in a much shorter period at 149 degrees F. Subsequent investigators substantiated and expanded such observations. The present pasteurization standards for milk are so adjusted that, at the temperatures employed, M. tuberculosis and all other disease-producing bacteria will be destroyed with a definite margin of safety remaining.

The significance of M. aureus and M. albus toxin production in milk and milk products is becoming increasingly more evident. In this disease nausea, diarrhea, headache, and cramps follow the ingestion of the toxin produced by the bacteria growing in the food. Thus it is termed food poisoning. The bacteria producing the toxin are destroyed by pasteurization but the toxin may survive boiling for 60 minutes. The bacteria producing the toxin enter milk and milk products through human handlers or directly from cows with mastitis caused by these organisms, the toxin producing micrococci. The only means of preventing occurrence of the disease is to prevent their entrance into dairy products (which is extremely difficult) and to prevent their growth prior to pasteurization by means of adequate refrigeration of the product. Entrance and growth of toxin-producing bacteria after pasteurization have resulted in serious food poisoning outbreaks in dairy products and emphasize the need for rigid sanitary care after pasteurization.

There are many specific examples of benefits of pasteurization in preventing or reducing incidence of disease through milk and milk products. A few might be mentioned in passing. Nathan Straus in New York waged a vigorous campaign to promote pasteurization of milk throughout the United States and Canada in order to reduce infant mortality widely prevalent at the time. Milk depots for distribution of pasteurized milk were established subsequently in a number of the larger cities in this country. As a result of the introduction of pasteurization in 1898 at Randall's Island hospital for homeless children in New York City, the infant mortality abruptly dropped from 41.81 to 21.75 percent. A striking example also has been given by Price (14). An examination of 300 tuberculous children in a Toronto hospital indicated 15 percent of them infected with extrapulmonary tuberculosis, presumably of bovine origin. Every one of these children had consumed raw milk and every one came from outside the city limits of Toronto. There were no Toronto children in the group because Toronto had enforced compulsory pasteurization of milk for many years. This is significant in view of the fact that a brief survey indicated that 26 percent of the pooled milk entering the Toronto pasteurizing plants was infected with Mycobacterium tuberculosis of the bovine type.

Common Lactic Acid Bacteria. The most frequently occurring lactic acid bacterium is Streptococcus lactis, the usual cause of souring of raw milk held at temperatures ranging from 50 or 60 degrees to 100 degrees F. It is easily destroyed by pasteurization. The same is true of Streptococcus cremoris, a close relative. Streptococcus thermophilus used in manufacture of cheeses such as Swiss and brick is able to survive pasteurization. It is, therefore, termed thermoduric (thermo - heat, duric - enduring). In other words, it is a bacterium that can survive pasteurization, but it does not grow at pasteurization temperatures. Bacteria that grow at pasteurization temperatures are termed thermophilic (thermo - heat, philic - loving). Streptococcus thermophilus is common in raw milk and therefore frequently is responsible for high counts of thermoduric bacteria in pasteurized milk. Streptococcus liquefaciens, a bacterium that also produces marked proteolysis in addition to rennin and lactic acid in milk and milk products is known to survive pasteurization.

The lactobacilli have figured prominently in manufacture of Cheddar and other cheeses from pasteurized milk. L. casei is known to bring about changes characterizing a desired degree of ripening in Cheddar cheese. Pasteurization is known to destroy large numbers of L. casei which is a common inhabitant of raw milk. Evans, Hastings, and Hart (15) found only 1/10 as many L. casei in pasteurized milk as in raw milk cheese from the same batch of milk. Other lactobacilli also may play a significant role in ripening of Cheddar cheese. Slater and Halverson (16) found that pasteurization at 143 degrees F. for 30 minutes or 160 degrees F. for 15 seconds destroyed approximately 52 percent of the lactobacilli found in raw milk cheese and suggest the acceleration of Cheddar cheese ripening by adding proper lactobacillis cultures to pasteurized cheese milk or by raising the ripening temperature to encourage growth of the reduced numbers of lactobacilli that survive pasteurization. Work of numerous investigators has resulted in inconsistent success in addition of pure cultures of lactobacilli and other bacteria to pasteurized cheese milk for the purpose of promoting the desired degree and type of ripening in the cheese. Raising the curing room temperature accelerates ripening but under practical conditions may lead to other undesirable effects. Enterococci have been shown by a number of workers to be present in pasteurized milk and in Cheddar cheese. Dahlberg and Kosikowsky (17) have reported that Streptococcus faecalis, an enterococcus, when added to pasteurized cheese milk produced a desirable ripened flavor in Cheddar cheese in 4.5 months at 50 degrees F. and in 2.5 months at 60 degrees F. The strain employed for their studies produced no toxin; however, toxin production by other strains of Str. faecalis has been reported.

Apparently much additional information must be developed before the problem of high-flavored cheese of Cheddar and other varieties from pasteurized milk has been solved. This one problem has definitely retarded universal pasteurization of cheese milk not only for Cheddar but also for other varieties such as Swiss cheese.

Micrococcus Species. This group has been important as a cause of high bacterial counts in pasteurized milk. They gain entrance on the farm from the udder, utensils, and other sources, sometimes in great numbers. Since a number of them are thermoduric they appear in the plate counts of the pasteurized product. According to Hucker, the most commonly occurring species found in pasteurized milk are Micrococcus epidermidis, Micrococcus candidus, Micrococcus varians, and Micrococcus luteus (18). Usually a thorough clean-up of milking machines and utensils on the farm results in a reduction in their numbers in the milk.

Microbacteria. This is another group of thermoduric bacteria that frequently go unrecognized. They have been found to survive the preheating and processing treatments in manufacture of dry milk and the pasteurization of market milk (19). Under certain conditions they may contribute significantly to the final plate count of the pasteurized or processed product.

Coliform Bacteria. The problem of coliform bacteria in pasteurized dairy products has been the seat of considerable controversy for many years. A presumptive test for coliform bacteria in pasteurized dairy products is run on the assumption that presence of coliform bacteria indicates either insufficient pasteurization or, more likely, contamination from improperly cleaned or sanitized equipment following pasteurization. Coliform bacteria, both Escherichia coli and Aerobacter aerogenes, are found on poorly cleaned equipment and may also enter dairy products through use of polluted water for washing equipment. The coliform bacteria in dairy products do not infect or produce diseases in persons consuming the products. The literature on the subject is too voluminous and controversial to review in this discussion. A number of workers have isolated strains of coliform bacteria that would survive the pasteurization of milk and cream, and consequently have questioned the validity of the coliform test on pasteurized dairy products. On the other hand, Crossley (20) pasteurized samples in the laboratory and found coliform bacteria in only 2 of 484 samples from bulked tank raw milk and in none of 493 samples from individual producers. Buchbinder and Alff (21) reported coliform bacteria in only 1 of 400 liters of milk sampled directly from the holder pasteurizer after pasteurization, and in about 50 percent of the same milk after it had been bottled. They concluded that heat resistant coliform bacteria were of no practical significance in the coliform test on pasteurized milk. Since coliform bacteria do grow in pasteurized milk and dairy products, Standard Methods for Examination of Dairy Products (22) specifies that samples be taken only on freshly pasteurized milk.

A most important requirement in cheese manufacture is the absence of appreciable numbers of coliform bacteria in the cheese milk. Because these bacteria, particularly Aerobacter aerogenes, produce such pronounced damage in the product in the form of gas and undesirable flavors, every effort must be made to eliminate them. They are one of the most important reasons for the steady increase in pasteurization of cheese milk. Also important in cheese manufacture is their elimination from equipment with which the pasteurized cheese milk comes in contact.

Nelson (10) reported survival of coliform bacteria in ice cream mix pasteurized at 145 degrees F. for 30 minutes, but at 150 degrees F. they were destroyed in 10 minutes.

Ropy Milk Bacteria. The most common cause of ropy defects in milk is Alcaligenes viscosus. Only in rare instances, usually where contamination is heavy, does Alcaligenes viscosus survive pasteurization and then grow in the pasteurized product. Prouty (23) reported an outbreak of ropiness in pasteurized milk due to a thermoduric micrococcus resembling Micrococcus cremoris viscosi. It was believed to have originated in the udder of a cow of one producer.

Water Bacteria. These include a number of Pseudomonas species such as Pseudomonas putrefaciens, cause of putrid and cheesy defects of butter, Pseudomonas fluorescens cause of rancid and decayed flavor in butter and other dairy products, Pseudomonas fragi cause of rancid and fruity flavors in dairy products, and Pseudomonas nigrifaciens cause of black discoloration of butter. All are easily destroyed by pasteurization of milk or cream and defects due to their growth in the pasteurized products indicate contamination after pasteurization, either from contaminated water or equipment. Certain of the Pseudomonas species are also important because of their ability to produce phosphatase in pasteurized dairy products.

Spore Formers. The spores of spore-forming bacteria usually are able to survive the pasteurization of milk although the less resistant spores may, in some cases, be destroyed. The higher pasteurization temperatures employed for cream, for example, may destroy appreciable numbers of the weaker spores present. Spores of some species are able to survive even the highest exposures in common use for pasteurization of milk products. Invariably where the number of spores present in the product before pasteurization is higher, the count after pasteurization will be proportionately higher. The spore is protected by a tough coat which is resistant to heat and other destructive factors. Vegetative cells contain no such protection and when a spore germinates to form vegetative cells it loses this protection. Usually excessive contamination of a product from soil, dust, or manure, increases the numbers of spores and may reduce efficiency of pasteurization. Another practice that leads to difficulty with heat-resistant spores in dairy products is repasteurization or reprocessing of a product. The original heat treatment usually destroys non-heat-resistant forms leaving spores and resistant vegetative cells. Where these have an opportunity to develop, especially in the case of spores, before the next processing, a selection of resistant cells or spores takes place and each succeeding processing of the product encounters more heat-resistant forms. This often results in a high percentage survival of bacteria in the finished product.

Most thermophilic bacteria that grow during vat pasteurization are spore formers. They usually belong to the aerobic spore-forming group, although 2 species of lactobacillus also have been reported responsible for thermophilic outbreaks in milk supplies. The thermophiles do not develop appreciably at temperatures of 160 degrees F. and higher, and therefore are not a great problem where higher pasteurization temperatures are used. If they have had a chance to develop during previous preheating or processing, they may survive the pasteurization process in large numbers. Some aerobic spore formers are important in dairy products because they are able to produce phosphatase in the pasteurized dairy products. Such strains have been isolated in some cases from products such as cream where they grow at refrigeration temperatures. In other cases thermophilic spore-forming bacteria produced phosphatase during vat pasteurization of milk.

The anaerobic spore-forming group, whose significance still is not adequately established in dairy products, also enters milk from soil and manure. The spores of many anaerobic spore formers are extremely heat-resistant and may survive even the more severe pasteurization exposures. The spores then may germinate in the final product to produce gassy and flavor defects. They are more important in cheese than in other dairy products.

<u>Molds and Yeasts</u>. Molds and yeasts in general are readily destroyed by approved pasteurization treatment of all dairy products. Both molds and yeasts also form spores, but in contrast to the bacteria, the spores of yeasts frequently are less heat-resistant than the vegetative cells. Mold spores usually are more resistant than the vegetative mycelium. According to Thom and Ayers (24) practically all mold spores are destroyed by pasteurization of milk at 145 degrees F. for 30 minutes. In a study of pasteurization of sweet cream Macy and coworkers (25) heated the cream to 150 degrees F. for 30 minutes and also heated samples from 145 to 165 degrees F. over a period of 30 minutes. In over 90 percent of the trials these treatments destroyed from 99.0 to 99.9 percent of the bacteria and in over 70 percent of the samples all yeasts present were destroyed. All of the molds in every trial were destroyed by either of the above treatments. Hunziker reported that 99.88 percent of the yeasts and molds were destroyed at 145 degrees F. in 20 minutes during pasteurization of cream, and 86.18 percent were destroyed by flash pasteurization at 165 degrees F., and that 98.9 percent were destroyed by flash pasteurization at 185 degrees F. Occasional heat-resistant strains of <u>O. lactis</u>, the common milk mold, and other molds are encountered but heat resistance of both yeasts and molds in the dairy industry is relatively unimportant in pasteurization.

<u>Comparative Efficiency of Different Forms of Pasteurization in Destruction of Microorganisms</u>

The League of Nations' report cited earlier indirectly indicates the differences in bacterial destruction that might be expected with some of the different methods of pasteurization. Any of the methods used can be made more effective within certain limits merely be increasing time and temperature of exposure. Wilster (26) has shown a greater bacterial destruction in pasteurization with the Vacreator at 190 degrees to 200 degrees F. than with vat pasteurization at 155 degrees F. for 30 minutes. In the case of market milk pasteurization numerous reports have indicated the holder method at 143 degrees F. for 30 minutes to be somewhat more effective in destroying thermoduric bacteria than the short time method at 161 degrees F. for 16 seconds (27). Ball (28) attributes this to the less lethal effect of the combination of pasteurization exposure and coming up and cooling periods in the case of high short pasteurization. These periods must receive as thorough consideration as the actual pasteurization temperatures and times if accurate evaluation of bacterial and enzymatic destruction is to be obtained.

Bacteriophage and Antibiotics in Cheese Milk. Bacteriophage is a virus that attacks and destroys bacteria. Bacteriophages specific for lactic acid bacteria used in cheese making have caused enormous damage in the cheese industry for years by stopping the necessary acid fermentation in the making process. Difficulty due to bacteriophage occurs more frequently with use of pasteurized milk than with raw milk, since in pasteurization lactic acid bacteria present in the raw milk are destroyed. Thus if bacteriophage destroys the lactic acid starter bacteria there will be no other lactic acid bacteria in the cheese milk to produce the necessary lactic acid during the making process. One source of bacteriophage is the cheese milk coming from farms or other plants. Pasteurization of the milk removes lactic acid producers and other bacteria but unfortunately does not destroy the bacteriophage. Nichols and Wolf (29) have shown lactic bacteriophage to resist heating to 158 degrees F. for 10 to 15 minutes and some strains survived 167 degrees for 7.5 minutes.

Studies in recent years also have shown that certain bacteria growing in cheese milk on the farm and enroute to the plant may produce substances therein that inhibit subsequent growth of the lactic acid bacteria during the cheesemaking process. These substances which are similar to the well-known penicillin and streptomycin in their effect also cause considerable damage in the cheese industry. They are termed antibiotics. Milk containing them often is known as non-acid milk. Whitehead and Riddet (30) demonstrated that such antibiotics could survive heating at 212 degrees F. for 30 minutes. Other investigators since have confirmed this fact. The answer to the problem of antibiotics in cheese milk must, of necessity, be strict sanitation on the farm to prevent their entrance and proper refrigeration to prevent their growth in the milk.

Effect of Pasteurization on Enzymes of Milk and Milk Products

Liapase. A number of investigators in the past have reported complete inactivation of lipase by the usual pasteurization treatments of milk. However, the recent report of Greenbank and Wright (31) suggests that the matter of lipase destruction by pasteurization should be reinvestigated. They reported that samples of dried whole milk prepared from milks heated for 30 minutes at 142 degrees, 152 degrees, or 162 degrees F., respectively, developed rancidity within 112, 126 and

140 days, respectively, when stored at 86 degrees F.

Phosphatase. The literature on destruction of phosphatase in milk and milk products by pasteurization is too voluminous to review at this time. A few reports might be cited to summarize the present information on the subject. Practically complete destruction of milk phosphatase occurs with holder and short time pasteurization of milk. Sanders and Sager (32) have reported an improved method which has been applied to cheese, fluid milk, cream, ice cream mix, sherbert mix, chocolate drink, butter, sweet buttermilk, cultured buttermilk, fermented milk drinks, goats' milk, and cheese whey to determine whether or not they or the products from which they were derived were adequately pasteurized.

One of the serious problems in the application of the phosphatase test to dairy products in the past has been the occurrence of false positive tests due to production of phosphatase by microorganisms. Tittsler, Sager, and Sanders (33) studied approximately 200 strains of microorganisms representing 90 species and 23 genera for production of phosphatase in milk and other media. Positive phosphatase tests at pH 10 were obtained with Aerobacter, Escherichia, Pseudomonas, Bacillus, Lactobacillus enzymothermophilus, Pencillium camemberti, Pencillium roqueforti, Aspergillus niger, and Aspergillus oryzae. Many of these gave negative tests in milk. All strains of Streptococcus, Leuconostoc, Lactobacillus, except for the one above-mentioned, Propionibacterium, Bacterium linens, Alcaligenes faecalis, Geotrichum candidum, and yeasts gave negative tests at pH 10. They concluded that the microbial phosphatases in dairy products can be distinguished from milk phosphatase by two methods. (1) Bacterial phosphatases are not inactivated appreciably at 70 degrees C. for 5 minutes while the milk phosphatase is destroyed completely at 70 degrees C. for 1.5 minutes. (2) Microorganisms that produce an alkaline phosphatase, active at pH 10, generally produce also an acid phosphatase active at pH 4 to 6 while the milk phosphatase is not active below pH 8.

A phenomenon not yet satisfactorily explained is the change of flash or high temperature pasteurized creams from negative to positive phosphatase value during storage. The same has been reported for butter made from flash pasteurized cream. Parfitt and Brown (34) reported that butters made from holder pasteurized creams gave negative phosphatase reactions but a large proportion of butters made from flash pasteurized creams gave positive reactions. Brown (35) found that of samples of butter changing from negative to positive during storage at 60 degrees F., 86.11 percent represented butter from high temperature pasteurized cream. Wiley, Newman and Whitehead (36) noted the same change in butter made from cream pasteurized with the Vacreator. They attributed the increase in phosphatase value to a binding of a small and varying proportion of the enzyme by the high temperature treatment in such a way that it escaped destruction during the brief heat treatment. The bound phosphatase was readily liberated by treatment of the cream with salt, sugar, or drying in vacuo.

Effect on other Enzymes. Amylase, a starch-digesting enzyme, also occurs in raw milk. It is destroyed by proper pasteurization. Leahy (37) developed a test for determining adequacy of pasteurization based on the presence or absence of amylase. The amylase test while fairly accurate lacked the sensitivity of the phosphatase test.

Another enzyme found in raw milk is peroxidase, which oxidizes certain other compounds in the presence of peroxides. Peroxidase is destroyed by heating milk to 175 degrees F. or higher. Two tests have been developed based on peroxidase destruction. One of these, the Storch test, indicates whether or not the milk was heated to 175 degrees F. or higher. A second, the Arnold, indicates absence of peroxidase in milk heated to 176 degrees F. or higher.

Raw milk also contains proteases which are protein-decomposing enzymes. Peterson, Johnson, and Price (38) have shown that pasteurization largely destroys the naturally occurring proteinase present. Their studies indicated that aside from rennet, the important source of proteinase activity during cheese ripening is from proteinase-producing bacteria. Their results on cheese ripening suggested that destruction of proteinase-producing bacteria by pasteurization was of greater significance in cheese ripening than destruction of the naturally occurring milk proteinase.

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THE OPERATION OF THE VACREATOR - STARTING, STOPPING AND CLEANING

by

H. E. Behlmer

Shortly after the Vacreator was introduced into this country the impression somehow was gained that it was a very difficult machine to operate. In fact, some plants hesitated to install Vacreators because they felt it would be necessary to hire men with engineering training to operate them.

Since then we have endeavored to remove this impression. The Vacreator is not a difficult or even a tricky machine to operate. It fell to my lot a fewyears ago to instruct a lady cheese maker in the operation of one of the large M Type machines and after only a few hours of instruction she was quite proficient in handling the machine. I think this is an indication that the operation of the Vacreator is quite simple.

In operating a Vacreator it should always be remembered that pasteurization with the Vacreator involves direct contact of steam with the product. For this a supply of clean dry steam is necessary. To insure clean steam it is necessary that proper attention be given to cleaning the boiler that firing be even, water level carried low, steam pressure high in order to avoid priming and a carry-over of foreign material. It is also recommended that a steam purifier be installed as an added precaution to insure clean steam.

In addition to these practices in order to insure clean steam it is necessary to drain the condensed water from the steam line before each starting of the Vacreator. Steam will condense very rapidly, especially on a cold day in an uncovered steam line. Quite often this condensed water is rusty or discolored in appearance from lying in the line, therefore is unsuitable for mixing with the milk product. In any case it is wet and will cause unnecessary dilution. Therefore, the first step in starting a Vacreator is to drain the condensed water from the steam line.

No. 3 and No. 6 Vacreators have a take-off from the main steam line for this purpose. This line is arranged to drain the condensed water into the lower part of the condenser.

The second step in starting the Vacreator is to sterilize it. Sterilizing of course, is not necessary each time the Vacreator is started but must be done the first time it is started each day. The most efficient and also the most practical method of sterilizing a Vacreator is by the use of steam.

Prior to turning steam into the Vacreator for sterilization, tension of the equilibrium valve tension spring should be slackened so that the equilibrium valve lever is free which will allow the steam coming from the pasteurizing chamber to pass the equilibrium valve float ball into the lower vacuum chamber. The vacuum breaking cocks on the machine should be opened and the hexagon nut at the bottom end of the pasteurizer should be loosened sufficiently to allow condensate to drain during sterilization. Also the hand clamps at the joint between the low vacuum chamber and the up-take pipe to the high vacuum chamber should be loosened sufficiently to allow air and steam to escape during sterilization.

Having thus prepared the Vacreator sterilization and starting can be accomplished by the following steps.

1. Open the steam valve to the pasteurizing chamber and the steam valve to high vacuum chamber sufficiently to keep a small amount of steam issuing from the vacuum breaking cocks and the drain at the lower end of the pasteurizing chamber. Continue this for at least 10 minutes to insure sterilization.

2. After 10 minutes of sterilizing tighten the joint at the low vacuum chamber outlet and tighten the hexagon nut at the lower end of the pasteurizing chamber, but leave the steam on. Close the vacuum breaking cocks.

3. Turn on the water to the water jackets. After about 5 minutes sufficient steam will have condensed in the high vacuum chamber to flood the discharge pump with sterile water. This water acts as a seal when the pump is started. If this pump is not sealed with liquid a vacuum cannot be drawn on the machine.

4. Close the steam valves and start the discharge pump. Some of the condensed water may be forced out through the discharge line. This should be allowed to run on the floor so as not to dilute the product.

5. Start the water pump and adjust its by-pass to give a water pressure at the condenser inlet that is approximately 10 pounds higher than the temperature of the water.

6. The vacuum should rise immediately. Both sides should be tested for maximum vacuum. To obtain maximum vacuum in the low vacuum chamber, turn the knurled knob on the snifter valve to the left to close this valve and prevent air from entering the low vacuum chamber condenser. If the vacuum does not rise to the desired maximum (28" or more) there is air leaking into the machine. It is assumed that the discharge pump is properly sealed with water, vacuum breaking cocks and drain connections closed, and the equilibrium valve is assembled properly. Place a finger on the inlet of

the snifter valve to make certain that air is not leaking through this valve. The snifter valve may be closed with a rubber stopper or cork during the testing operation if desired. Then go over all joints, tighten hand clamps, and unions from the inlet valve consecutively to the discharge pump. Air leaks can be detected by applying a heavy soapsuds or a lighted match or candle along all joints.

7. When it becomes apparent that there are no air leaks, turn the snifter valve adjustment screw to the right until the vacuum on the low vacuum side is reduced to 20". This may depress the high vacuum by about 1" if the intermediate valve is seating properly. If this valve is not seating, the vacuum on the high vacuum side will also drop and this will indicate the necessity of checking this valve before the next run.

8. Open the main steam valve until the desired rise in temperature of condenser water is reached. Increase the spring tension on the equilibrium valve until the pasteurizing thermometer indicates the required pasteurizing temperature.

9. The in-feed pump can now be started. When the product starts to flow through the pasteurizer, adjust the equilibrium valve spring to set the pasteurizing temperature at the desired point. Increase the steam flow as may be necessary to maintain the desired temperature rise on the condenser water and make a further and final adjustment of the equilibrium valve tension. If the steam distillation temperature is not sufficiently high adjust the snifter valve until the vacuum is reduced to the desired temperature point. As the grade of product is lower so must the temperature in the low vacuum chamber be higher and the vacuum lower. It is not wise, however, to depress the vacuum below 14" - 182 degrees F. as the machine will not operate steadily below that point. The vacuum in this chamber is best carried at no higher than 20" or lower than 15".

10. Adjust the water on the water jackets so that it does not overflow the jackets and so that the discharge from the jackets is at a temperature of from 120 to 140 degrees.

When the product supply ceases, the Vacreator will continue to run without damage or trouble. As steam, water, and power are thus being wasted, it is not wise to keep it so running for long periods. Should it be desired to keep the machine standing under vacuum, between runs, it is best to shut off the steam but the water pump and discharge pump must be kept in operation. If the operation of the Vacreator cannot be continuous, the machine can easily be shut down between runs. One of the advantages of the Vacreator is that the process can be readily interrupted and the machine be started without any ill effect on the product.

To shut down the Vacreator follow this sequence.

1. Stop the in-feed pump.
2. Slacken the tension on the equilibrium valve spring.
3. Shut off the steam.
4. Open the vacuum breaking cocks.
5. Stop the water pump.

6. Stop the discharge pump.
7. Hose the machine down with cold water.
8. Shut water off the water jackets.

Cleaning the Vacreator is best done by circulating an alkaline cleaning solution through the machine followed by circulating an acid cleaner. Inasmuch as alkaline or acid cleaners cause wear on Waukesha Pumps, the use of the in-feed pump furnished with the Vacreator for pumping cleaning solutions should be avoided for this purpose.

For circulating a cleaning solution a Model AH Flex-flo pump is recommended. The impeller of this pump should be trimmed to give a flow of approximately double the rated capacity (at 30 P.S.I.) of the Vacreator.

Also, as only about 5 gallons of circulating solution are required for the Vacreator, it is recommended that a small surge tank be provided for the cleaning solution supply rather than using a forewarmer or other supply tank for circulating. This will allow cleaning the machine with a minimum amount of detergent or acid cleaner.

Follow this procedure for cleaning:

1. Rinse the machine to push out the last of the milk product. Keep the machine running with about half the steam used in vacreating. Reduce the spring tension on the equilibrium valve to give a pasteurizing chamber temperature of from 175 degrees to 180 degrees F.

2. Disconnect the sanitary piping from the in-feed pump to the Vacreator and connect piping from the circulating pump and circulating tank to the pressure inlet valve of the Vacreator. Turn the discharge line from the Vacreator to the circulating tank (by means of the 3-way valve in the discharge line).

3. Mix one pound of alkaline detergent in about 5 gallon of hot water in the circulating tank. Cherry-Burrell High Speed No. 2 is recommended for this purpose.

4. Circulate this cleaning solution through the machine for 10 to 20 minutes, depending on the volume of product processed.

5. Discharge the cleaning solution to the floor and flush the Vacreator with water for 3 to 5 minutes to remove the alkaline detergent and suspended milk solids.

6. Mix one-half to one pint of acid cleaner such as Cherry-Burrell Auxiliary Cleaner in hot water in the surge tank.

7. Circulate the acid cleaner for 10 to 20 minutes, depending on the volume of product processed.

8. If the machine is to be dismantled immediately, it should be drained and brushed where necessary and then rinsed. When the cleaning job is to be completed the next morning, the machine may be filled with water and held this way over night. The machine is then dismantled, brushed and rinsed before reassembling.

9. The reassembled machine should be steam sterilized before use each day for at least 10 minutes to sterilize all parts.

The amount of burn-on in a Vacreator will vary according to the length of operation and the amount of product processed. When the time of processing is as long as 6 to 8 hours, it is well to use the full 20 minute circulation on both cleaning solutions. It is also helpful to repeat the alkaline cleaner circulation after the acid where long runs are encountered.

PHYSICS AS IT APPLIES TO THE VACREATOR

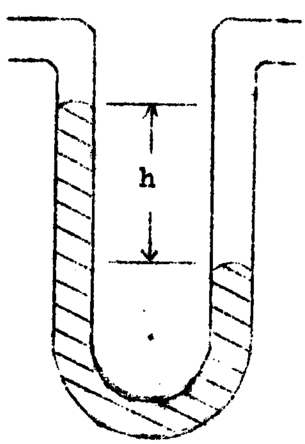
by

Fred W. Decker

The Vacreator embodies a number of physical principles studied in mechanics and heat. In this discussion we examine the following topics from physics as we find them demonstrated in the Vacreator:

1. Pressure and pressure measurement
2. Expansion of gases
3. Evaporation and boiling
4. Pressure operated valves
5. Aspirator pumping
6. Specific gravity
7. Specific heat

Pressure is defined as force per unit area over which the force is applied. It is expressed, for example, in pounds per square inch. At sea level the atmosphere exerts a pressure of about 14.7 pounds per square inch. A U-tube manometer can be used to measure differences in pressure. It consists of a piece of glass tubing bent into the form of a U and containing some mercury.



In this manometer the left-hand arm of the tube is connected to a vacuum pump which removes all of the air normally exerting a pressure upon the surface of the mercury in that arm. The right-hand arm of the tube is open to the atmosphere, so the mercury has acting upon it the full pressure of the atmosphere. The mercury in the right-hand arm is depressed, therefore, until the weight of the left-hand mercury column of height h produces a pressure at level A which is equal to the atmospheric pressure. This is essentially the function of a mercury barometer. At any location the atmospheric pressure rises and falls, but on the average the heights of mercury, h, at various altitudes are as follows:

TABLE I

Height (feet)	Pressure, inches of mercury	"Vacuum" inches of mercury, with respect to zero vacuum at sea level.
0	29.9	0
1,000	28.8	1.1
2,000	27.8	2.1
3,000	26.8	3.1
4,000	25.8	4.1
5,000	24.8	5.1
6,000	23.9	6.1
7,000	23.0	6.9
8,000	22.2	7.7
9,000	21.3	8.6
10,000	20.5	9.4

If the left-hand arm is connected to a region of "partial vacuum," the height h will be lower than for a perfect vacuum. Therefore, we may indicate the degree of evacuation of a chamber in terms of "inches of vacuum," meaning the height h of the mercury column when the left-hand tube arm of the U-tube manometer is connected to the chamber under study. Apparently the vacuum gauge calibrated in this manner and connected to a chamber which has been completely evacuated will indicate a reading in "inches of vacuum" which depends upon the outside air pressure.

The Bourdon gauge is the principle ordinarily employed to measure pressure differences when it is desired to have a dial-indicating instrument. A piece of flatlined metal tubing of oval cross-section is bent around a circle. The interior of the tube is connected to the region in which the pressure is to be measured, while the exterior is exposed to atmospheric pressure. If the pressure in the region under test is higher, the curved tube will "unwind". If the pressure is lower, i.e., if a "partial vacuum" exists, the tubing will be bent more sharply. A suitable leverage system transmits these movements of the tubing to the gauge needle. The dial can be marked for the corresponding heights h of the U-tube manometer in "inches of mercury."

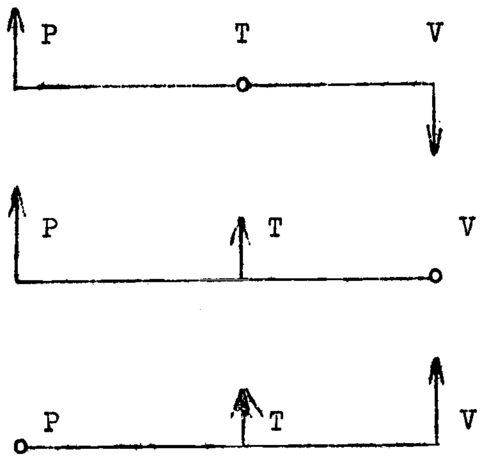
In the vacreator we find vacuum gauges with dials marked in "inches of mercury," indicating the degree of vacuum in terms of the mercury column supported by atmospheric pressure against the pressure inside the gauge. Of course, such a gauge will not indicate a greater difference in pressure than the prevailing atmospheric pressure.

If the equipment is located at some other height than sea level, the needle may be set so that "zero inches of vacuum" will be indicated when the chamber to which it is connected has a pressure equal to the atmospheric pressure at sea level, i.e., 29.92 inches. In this case, for example, the gauge will indicate "9 inches of vacuum" when located at 9500 feet if the pressures inside and outside the chamber are equal.

Expansion of a gas depends upon changes in the pressure and temperature of the gas. The relations of pressure, temperature, and volume are expressed in the gas law:

$$\frac{PV}{T} = \frac{P'V'}{T'}$$

This formula can be interpreted in terms of a simple lever:



The temperature is referred to absolute zero, -459 degrees F.

<u>Evaporation</u> is the process by which a substance changes from the liquid to the gaseous state. If water is contained in a closed chamber from which all air has been removed, the water will evaporate until a certain pressure is established within the chamber. This "saturation vapor pressure" depends only upon the temperature:

TABLE II

Temperature (Degrees F)	Saturation Vapor Pressure (Inches of Mercury)	Vacuum, Referred to Sea Level Pressure of 29.9 Inches of Mercury (Inches of Mercury)
80	1.0	28.9
90	1.4	28.5
100	1.9	28.0
110	2.6	27.3
120	3.4	26.5
130	4.5	25.4
140	5.9	24.0
150	7.6	22.3
160	9.6	20.3
170	12.2	17.7
180	15.3	14.6
190	19.0	10.9
200	23.5	6.4
210	28.7	1.2
220	35.0	(-5.1)

In the second column the saturation vapor pressure is expressed in inches of mercury with respect to a perfect vacuum. This is often called "absolute pressure."

Evaporation occurs at any temperature. For example, clothes drying on the clothesline become dry by evaporation. The liquid molecules become detached from each other at the surface of the liquid and mingle with the air, giving no other evidence than a gradual disappearance of the liquid.

Boiling, on the other hand, is a violent process in which the liquid is heated until bubbles of vapor form within the liquid and rise to the surface. In order for these bubbles of vapor to form, the temperature must be high enough for the saturation vapor pressure to equal the pressure of the atmosphere above the liquid. Evidently, then, the foregoing table of temperature versus saturation vapor pressure is also a table of boiling point temperatures versus atmospheric pressures. Now it should be apparent that boiling occurs at lower temperatures whenever the pressure is lower and at higher temperatures whenever the pressure is higher than sea level atmospheric pressure.

In the vacreator the "vacuum" in the pasteurizing section is 6 to 12 inches of mercury. Referring to Table 2, we see that the boiling temperature is about 190 degrees F. to 200 degrees F. Similarly, boiling occurs at 160 degrees to 180 degrees F. in the second chamber where the "vacuum is 15 to 25 inches of mercury and at about 110 degrees F. in the third chamber where the "vacuum" is about 28 inches of mercury.

Evaporation is a cooling process because a large amount of heat is used up to convert a small amount of liquid water into vapor. When the boiling point is reached, the temperature will remain constant until all of the liquid is converted to vapor. During this process all heat supplied is used in converting the liquid to vapor. If the pressure is reduced, the temperature of the liquid will fall to the new boiling point temperature due to the cooling effect of the evaporation.

In the vacreator heat is supplied in the steam added to the product so that the product is always at the boiling temperature corresponding to the pressure (or "vacuum") to which it is subjected. Hence, the vacuum gauges may be read to determine the temperature of the product if the gauge needle has been set so that zero vacuum is indicated when the pressure in the evacuated chamber is equal to that of the atmosphere at sea level. The first and third columns of Table 2 give this conversion.

Conversely, condensation is a heating process in which the latent heat of vaporization is released as the vapor returns to the liquid state. In the vacreator condensation occurs at the ejector condenser where the vapor comes into contact with a high velocity jet of cool water. As the temperature of the water is less than that of the boiling point corresponding to the pressure of the vapor around it, the opposite of evaporation occurs. The heat given up in condensation is evident in the increased temperature of the water leaving the condenser.

The aspirator pump used in the ejector condenser reduces the pressure in the vacreator in much the same manner as the ordinary household spray gun reduces pressure so as to draw a liquid up from the reservoir. In the household sprayer a high speed jet of air is directed over the end of a tube, where the pressure is reduced so that atmospheric pressure acting on the surface of the liquid in the reservoir forces it aloft. It is a general principle in physics that whenever a moving fluid is made to travel faster by being confined to a narrower channel, the pressure at that point is decreased. In the vacreator ejector condenser the mixture of air and steam rushes into this region of low pressure around the jet. The steam condenses as mentioned above, and the air, carbon dioxide, and other gases are entrained as very fine bubbles in the stream of water, giving it a milky appearance. The degree of vacuum which can be reached with this type of pump depends upon the temperature of the water stream. When the temperature is high, the stream will boil at "lower vacuum." Table 2 indicates, therefore, the highest "inches of vacuum" which may be attained for a given water temperature.

Pressure operated valves such as the "snifter" valve for admitting air into the second chamber are actuated by the balance of forces between the outside atmosphere and the interior partial vacuum. If a diaphram mounted between two springs is attached to a needle valve, the spring tension can be adjusted so that the needle valve will be opened when the atmospheric pressure exceeds the partial vacuum pressure by more than a given amount. In the vacreator the opening of this needle valve admits air to the second chamber so as to reduce the pressure difference (reducing the "vacuum").

Specific gravity is the ratio of the density of a substance to that of water. In the metric system one gram of water occupies one cubic centimeter. If some other liquid weighs 1.1 grams per cubic centimeter, we say that it has a specific gravity of 1.1. Hence, specific gravity is the ratio of the weight of a given volume of a substance to an equal volume of water. In many industrial applications a popular method of measuring the specific gravity is to observe how low a given float will sink when placed in the liquid. The "lighter" the liquid, the deeper will the float sink until it becomes completely submerged. This is the principle of the battery hydrometer, which is marked ordinarily in terms of the specific gravity. In many chemical and food industry processes another system of hydrometer marking is used called the Baume' scale marked in Baume' degrees. For liquids heavier than water the specific gravity can be found from the Baume' scale (heavy) by using the following formula:

$$\text{sp. gr.} = \frac{145}{145-(\text{Baume' degrees.})}$$

Specific heat describes the relative difficulty of heating a substance. The unit of heat is the British thermal unit (Btv), the amount of heat required to raise one pound of water one degree Fahrenheit. Hence, the specific heat of water is 1 Btu/lb/degrees F. It might be remarked at this point that to convert one pound of water to steam at sea level atmospheric pressure where the boiling point is 212 degrees F. requires 972 Btu. This latent heat is released to heat the ejector condenser water stream when the steam condenses, as mentioned above. The rate of heating in the condenser is therefore quite high, and a continuous flow of water prevents excessive rise of temperature, which would reduce the degree of vacuum which can be reached with this pump.

INSTRUMENTATION OF VACREATOR

by

G. E. Heller
Taylor Instrument Companies

The first and most important step in the proper selection of instruments for any process is to determine the variables which affect the quality or efficiency of the operation. Once it has been determined which variables are to be controlled, and the order of accuracy which is necessary, then usually adequate instruments can be selected to give the desired control. In the Vacreator, the variables which fall into the above category could be listed as follows. These are not necessarily listed in the order of importance.

1. Rate of product flow.
2. Rate of steam flow to pasteurizing chamber.
3. Pasteurizing temperature.
4. Quantity of excess steam or treatment intensity.
5. Final discharge temperature.

As small changes in product flow do not seriously affect the operation of the Vacreator, the normal constant displacement pump is considered to give adequate control of this variable. It is true that more elaborate control could be supplied. One of the criterions of good instrumentation is not to add complexity beyond that required to maintain the desired or necessary accuracy.

As variables 2, 3, and 4 are interrelated, the proper instrumentation of these items will be covered together. As the steam entering the pasteurizing section furnishes the necessary heat for bringing the product up to the pasteurizing temperature and also the excess steam for distillation, it is imperative to consider these two items together. As the product falls through the steam vapors in the pasteurizing section it approaches the steam temperature. Accepting this as a true statement, then the simplest control which could be applied to the pasteurizing temperature would be to control the absolute pressure existing in the pasteurizing chamber. However, if only enough steam was admitted to maintain the absolute pressure at the desired points, there would be no assurance that any excess steam was available. If one attempts to control the pasteurizing temperature in this manner, there would be no assurance that an excess quantity of steam was provided for treatment. In order to insure an excess quantity of steam under these conditions, it would be necessary to bleed a fixed quantity of steam from the pasteurizing chamber to the second chamber of the Vacreator. Although this scheme of instrumentation would be very simple, it would be extremely difficult to apply as it would necessitate radical changes in design.

A more practical, but slightly involved, method of accomplishing the desired purpose of insuring excess steam and uniform pasteurizing temperatures, would be to control the flow of steam to the pasteurizing chamber, and regulate the temperature by adjusting the position of the equilibrium valve between the first and second chambers. It is immediately apparent that the success of this method depends primarily upon whether or not the product has reached the steam temperature, as the excess steam and product pass out of the chamber through the equilibrium valve. Tests have indicated that the product does approach the steam temperature; therefore, this method of operation should be considered satisfactory.

The simplest method of controlling the quantity of steam flow through the pasteurizing chamber is to control the pressure ahead of the fixed orifice. The instrument required for controlling the pasteurizing temperature would be one with proportional response and automatic reset, which automatically adjusts the spring tension on the equilibrium valve. These two instruments have been given extensive field tests, and have proven to be entirely satisfactory.

Variable 5, the final product temperature, is important. It is obvious that if the final product temperature is above the inlet temperature, then some steam condensate must have been added to the product. If the final product temperature is below the inlet temperature, then it is equally obvious that some of the product has been evaporated.

The most direct method of insuring the proper outlet temperature would be to measure the inlet temperature, and adjust the absolute pressure of the final chamber accordingly. This instrumentation has been considered, but up to the present time has not been tried out in the field. However, as the problem of controlling these variables is simple, there can be no doubt that this instrumentation would give the desired results.

In order to guarantee that the product being produced by the Vacreator is always satisfactorily pasteurized, it is necessary to provide various safety devices. The primary device is a Safety Thermal Limit Controller which measures the temperature of the product as it leaves the pasteurizing chamber. If for any reason the product falls below the set point of this instrument, it operates to stop the product pump thus assuring that no additional material which has been improperly pasteurized can pass through the unit. Although this is the recommended method of insuring a satisfactory product, there are certain other means which could be employed. For example, a Flow Diversion Valve could be used at the discharge of the final chamber, which could be arranged with a time delay device that would insure that all of the product passing through the unit had reached a satisfactory pasteurizing temperature.

It is felt that the proper application of instruments to the Vacreator will certainly increase its versatility, and make it much easier to operate. As more experience is gained in the handling of products other than milk, there is definite chance that some of the variables which have been covered in this brief discussion will need to be more closely controlled than would be possible with the type of instruments included in this paper.

VACREATION OF CREAM FOR BUTTER

by
H. E. Behlmer

The preparation of cream for pasteurizing with a Vacreator is practically the same as preparing cream for pasteurization with other types of pasteurizers. Cream may be graded into the same grades as is customary in the plant and each grade vacreated separately. It may be possible after experience is had with the Vacreator to add to the first grade cream some cream of a somewhat lower quality.

Where weed flavored cream is encountered, it should be mixed with cream of the same grade and treated together. In other words, cream that is of good quality or Grade 1, with the exception of its containing the weed flavor, should be mixed and treated with Grade 1 cream. Cream that is weed flavored and is poor quality in addition, or second grade, should be mixed and treated with second grade cream.

By mixing the weed flavored cream with cream that is free from weed flavors the flavor substances are spread over a larger bulk of cream. Thus, the flavor bases by becoming diluted are more easily removed by the steam distillation treatment.

Standardizing for acidity may be accomplished with the same neutralizers and using the same procedure as is done with vat pasteurization except that in the case of high acid cream, the use of bicarbonate of soda or neutralizers containing ahigh percentage of bicarbonate of soda, or other neutralizers that cause excessive foaming should be avoided. Generally speaking, cream testing over .7% acidity should be neutralized with a special alkali or lime, or at least to about 0.3% or 0.4% with special alkali or lime and the rest of the way with carbonate neutralizers if desired.

It is recommended also that neutralizer be added when the cream is at a temperature of about 80 degrees F. After standardizing for acidity, cream in the forewarmer should be pre-heated to 110 degrees - 115 degrees before entering the Vacreator. Higher forewarming temperatures are not recommended as they tend to cause serum impurities to be absorbed into the fat. Heating to 110 degrees allows the action of the neutralizer used to proceed to the point before pasteurization where the coagulation of the casein is minimized. This prevents the locking-up the fat particles by the casein which cause loss of fat in the buttermilk and prevents them from receiving their proper cleansing action by the steam. It also avoids dilution arising from vacreation which further tends to lower fat losses.

Good quality cream may be treated at any flow up to the full capacity of the Vacreator (6000 lbs. per hour in the No. 6 Vacreator - 3000 lbs. per hour in the No. 3 Vacreator). Since reduction in flow allows more intensive treatment, lower grade cream should not be treated at the full Vacreator capacity, but should be reduced progressively as the grade of cream is lower.

The pasteurizing temperature is best maintained at 200 degrees F. Although efficient pasteurization occurs at temperatures as low as 190 degrees F., higher temperatures insure a greater excess of steam for the cleansing action and greater bacterial destruction.

The vacuum in the second vacuum chamber should not be higher than 20" nor lower than 15". As the grade of the cream is lower (either due to weed flavors or otherwise), so must the temperature of the second chamber be higher and the vacuum carried lower.

The vacuum in the final chamber should always be dept as high as possible. This is extremely important. It means a greater elimination of odors, reduction of dilution, improvement of flavor, and more cooling.

SHORT COURSE IN VACREATION

VACREATION OF ICE CREAM MIX

Early Application - Experiment Stations - Commercial Pioneers - Conclusions

F. S. Board

As is now well known, the Vacreator was developed by H. Lamont Murray and F. S. Board in New Zealand for the pasteurizing and processing of cream for butter.

It was, during the early years, thought not to be possible to vacreate ice cream mix successfully.

However, in Australia, during the 1938-39 season, Lamont Murray inspired the undertaking of experiments and writing to the author from Auckland, New Zealand, on March 3, 1939, he had the following information to impart:

> "In a recent letter you enquired whether we had managed to do anything in connection with the possible utilisation of Vacreators in the Ice Cream Industry, and I am very pleased to be able to send you some interesting information regarding developments in this direction.
>
> We persuaded Peters Ice Cream Co. whose head Factory is at Redfern, Sydney, and who have six other places throughout the Commonwealth, to permit us to demonstrate the treatment of several batches of mix. For the purpose we utilised the Baby unit recently installed at Hawkesbury Agricultural College, N. S. W. Batches of various types of mix were transported to the College, and in the presence of Peters' Representatives we treated them at varying pasteurising temperatures and steam distillation intensities. The unit treated the material with the greatest of ease, there being no CO_2 gas load.
>
> Bacterial Examinations of the treated batches were made, both by Hawkesbury College and by Peters' staff, and in all cases the counts were negative. The batches were transferred to Peters' factory and made up into frozen products. The results were extremely encouraging, and in some directions, totally unexpected. The products were definitely more delicate and uniform in flavour, and smoother to the tongue. It was found a greater degree of swell was obtainable than formerly, and strange to say, the product stood up for a considerably longer period without melting. In no direction was it found that Vacreation was other than distinctly beneficial as compared with their ordinary methods of treatment.

Peters Company were very distinctly impressed, and after we left Australia, lest there should be a nigger in the wood heap somewhere, they decided to repeat the experiment without acquainting either Wildridges' or ourselves. This they did, and the results wholly confirmed our earlier findings.

As a consequence, when I was over in Sydney on this recent visit, Peters Company placed their order for a large 'M' type unit and propose to treat the whole of their Sydney product in this manner."

Upon receipt of this letter the author acquainted Dr. G. H. Wilster, Oregon State College, of the Australian development wherewith the Oregon Experiment Station made experiments in the use of the Vacreator for pasteurizing ice cream mix.

The results of these experiments and later work have been given to you by Dr. Wilster in his preceeding paper. You will have observed that these results were very satisfactory.

Dr. J. J. Willingham of Iowa State College, Ames, Iowa, made a statement in 1942, from which is excerpted as follows:

"Not until August, 1939, was consideration given in our department to the possibility of vacreating ice cream mix. This followed advice to our staff by Mr. F. S. Board that H. L. Murray, who developed the Vacreator and the process of vacreation, had discovered in Australia that ice cream mix could be successfully vacreated, and that thereafter, ice cream mix was being satisfactorily vacreated at Oregon State College. Mr. F. S. Board is the business and technical representative of Mr. Murray (who is a resident of New Zealand) in this country.

Because of the past experience in the industry of the detrimental effect of high temperature treatment when pasteurizing temperatures in excess of 170 degrees F. were employed I and my co-workers were doubtful of the possibility of advantageously treating ice cream mix in the Vacreator with the mix particules coming into contact with steam at temperatures from as high as 190 degrees to 200 degrees F. Attempts in the past to subject ice cream mix to such high temperatures by other known methods had resulted in sugar caramelization, protein destabilization of milk, eggs, agar and gelatin, producing extreme cooked flavor and body and texture defects. It was therefore with considerable scepticism that I consented to run experimental batches of ice cream mix through the Vacreator. The good effect of this treatment on these initial mixes was most surprising and unexpected. Subsequently over a period of several months considerable experimental runs were made. These studies were reported on by Dr. N. E. Fabricius.

In passing ice cream mix through Murray's Vacreator the mix is heated to pasteurizing temperature in direct contact with steam of adjusted temperature, is steam distilled, deaerated and cooled to approximately blood heat as it flows continuously and rapidly through the three vacuum zones. The effect I have observed on the ice cream made from mix treated by the process of vacreation is high pasteurizing efficiency, removal of objectionable weed and feed flavors and retention of natural flavor without development of cooked flavor, reduced viscosity of the mix which improves whipping ability and produces a finer body and texture of the ice cream with a more silky or velvety melt down in the mouth. I have also found that the ice cream made from vacreated mix stands up better and has a much better keeping quality in storage than when made from mix pasteurized by the usual batch method. In this connection an important difference is that whereas ice cream made from mix pasteurized by standard methods often develops oxidized flavor during storage the ice cream made from vacreated mix did not develop oxidized flavor during storage. This is probably due to the dissociation of dissolved and diffused oxygen from the mix particles at the time of exposure to high temperature in the Vacreator pasteurizing section.

Some other advantages of the vacreation method of pasteurizing and processing ice cream mix are (1) a continuous method of treatment is provided, (2) homogenizing temperatures can be considerably reduced, (3) a much smaller quantity of expensive flavoring material is needed to impart a desirable degree of flavor to the ice cream, (4) the use of butter in periods of cream shortage is greatly facilitated as in this process the fat and water go readily into emulsion."

Dr. N. E. Fabricius of Iowa State College, Ames, Iowa, reported to the 40th Annual Convention, International Association of Ice Cream Manufacturers, Ltd. at Atlantic City, N. J. (U.S.A.) October 24, 25, 26, 1940, on the studies made in the use of the Vacreator for pasteurizing ice cream mix. Dr. Wilster has given you an outline of this report in his preceeding lecture.

At Oregon State College the results of the studies, made during 1939, led to the adoption of the vacreation process as standard practice in the manufacture of all the ice cream made in the dairy products laboratory and such practice has continued to this day with results that have been reported in Experiment Station Bulletin 430, July, 1945, as being very satisfactory.

At the I.N. Hagan Ice Cream Company's plant, Uniontown, Pennsylvania, a Junior size Vacreator has been in use, for pasteurizing the ice cream mix, since 1941. This was the first commercial plant in the United States to vacreate ice cream mix. This pioneer establishment manufactures high-quality ice cream in substantial amounts. Mr. I. N. Hagan, president, very graciously agreed to have Wilster and Board spend some time at this plant, to conduct tests, during January, 1945. Of the results on the quality of the vacreated ice cream, made during the test runs, it is reported in Oregon Experiment Station Bulletin 430, July, 1945:

"The mix was simple in composition. It consisted of: cream, milk, sugar, egg yolk, and gelatin. Pure vanilla was added before freezing. Each sample was given a code letter and was critically examined by eight persons. All samples were pronounced excellent. No undesirable flavor could be detected. The vanilla flavor was not pronounced. It was believed by the management of Hagan's that a strong, or pungent, flavor is undesirable in fine quality ice cream. Although the solids - not - fat content was somewhat lower than in pre-war ice cream, the body and texture were very good.

The texture was smooth and the body firm. The melt-down quality of all samples was excellent."

From a paper given by Mr. Hagan at the Ohio State University Dairy Conference, February 10-14, 1947, is culled the following:

"Our experience with vacreation dates back to 1941 when, so far as we can ascertain, ours became the first installation in the United States confined exclusively to the manufacture of ice cream.

Vacreation has been defined as a method by which milk and milk products can be pasteurized with an extremely high destructive effect on bacteria, yeasts, molds, while at the same time any weed and feed flavors are removed; but with a refinement that protects natural flavor and preserves inherent food qualities . . . . The points of superiority to this type of pasteurization are obvious. A distinct improvement in flavor is attained by the positive removal of undesirable weed and feed flavors oftentimes unavoidable in the raw materials. A retention of the fine natural cream flavors is realized, greatly enhancing the quality of the finished product. It seems, too, that our troubles with oxidized flavors have vanished also. The viscosity of the resultant mix is likewise reduced. All in all the Vacreator does a superb job in processing ice cream mix and we are happy to endorse it."

In reporting on pioneer installations of the Vacreator, in the ice cream industry, the enterprise of the Tip Top Ice Cream Company in Auckland, New Zealand, must not be overlooked. In 1940 Murray, desiring to make further observations of the effect of the process of vacreation on ice cream mix, under commercial conditions, at a convenient point where scientific control could be maintained, arranged to install a Vacreator in the Tip Top Company's plant. The unit was later purchased and is today in regular use in the standard manufacturing operation of this company. The managing director of the Tip Top Company has recently gone on record with the following statements:

"We can boldly state that we are convinced that it (the Vacreator) is indispensible in our ice cream manufacturing operations" . . . . "We have found the Vacreator to be a most efficient and reliable pasteurizer and this has been exemplified by our daily routine bacteriological analysis which, in turn, is regularly confirmed by an independent public bacteriologist. Seldom does our plate count exceed 800 in the finished ice cream" . . . "We like the continuous feature and standard regularity of operation under seasonal changes and variations of ingredient characteristics" . . . "Particularly, we like the unmasking and retention of natural creamy flavor" . . . "We have found that the incorporation of butter in some of our mixes is greatly facilitated" . . . "We have experienced practically no shrinkage of our product in transportation and, therefore, no credit claims in this respect" . . . "The operating cost and the cost of upkeep of the Vacreator installation is extremely low."

In the United States and Canada the adoption of the Vacreator by the ice cream industry has been slow for two very good reasons: The war and post-war era imposed such restrictive conditions on Vacreator manufacture that machines simply were not available for, yet, unexploited branches of dairy manufacture and, furthermore, it was a deliberately adopted policy not to attempt to promote the Vacreator in the ice cream field, in a big way, until the equipment could be supplied entirely in stainless steel, including the pumps. The day has at last arrived when complete Vacreator units can be supplied in quantity fabricated wholly of stainless steel. In the meantime, and during the nine years that have elapsed since Murray made his first experiments in Australia, some eight plants have installed and are using Vacreators for pasteurizing ice cream mix in the United States and Canada. These users are regarded as being pioneers. Since all-stainless American manufactured complete Vacreator units became available, starting early this year (1948), machines have been installed in a number of plants, for pasteurizing ice cream mix, with many more on order and yet to be delivered. From the pioneer commercial plants has come, from time to time, reports of progress and strong support for this use of the Vacreator. The following are gleanings from these reports.

> "When our ice cream mix has been off flavor, due to some slightly garlic cream having been used, we re-pasteurized it through the Vacreator. It came out free of all off flavor and odor" . . . .

> "We wish to say that we have used the Vacreator since the spring of 1942. We have had good results in vacreating our ice cream mix. After vacreating the mix for some time, we made mix once without the Vacreator. Our mix customers wanted to know at once what was wrong with our mix. They claimed it did not have the clean flavor as before" . . . .

> "The procedure as outlined at the bottom of page 8 (Oregon Agricultural Experiment Station Bulletin 430 - July, 1945) is so nearly the same as we use that I hesitate to elaborate further on the use of the Vacreator. It was largely from this bulletin that we derived our knowledge of the use of this equipment. Reading further, on page 9, of the same bulletin, sums up our experience, too, as to results. I am certain I could not express these experiences better or more accurately" . . . .

> "We have now used a Vacreator for this purpose (pasteurizing mix) for the past four years with very satisfactory results. The mix is first prepared in the usual manner and neutralized if necessary. We find it requires a little less neutralizer when using the Vacreator. The mix is then heated to viscolizing temperature, viscolized, and then put through the Vacreator where it is heated to 195 degrees F. and cooled immediately. We find this procedure removes any off flavors which might otherwise affect the mix and gives us a uniform clean flavored ice cream" . . . .

> "We have been using our Vacreator for about four years and have always obtained good results with it. Most of our mix is made from milk and sweet butter. I have often heard experts say that mix run through a Vacreator will have a caramel or burnt flavor, however, we have never noticed this. Our customers say our ice cream is the only ice cream made from real sweet cream althouth we have never advertised our ice cream as such and never will until it is true. I'm convinced that the Vacreator is the answer for making good ice cream with a nice clean fresh flavor." . . .

"The customer has indicated that their mix is now a very superior product, with an excellent flavor and with no trace of the 'cooked' flavor that had been prevalent in their batch pasteurized mixes. Further, because of the use of the Vacreator, the customer has been able to reduce the day's operation tremendously.

"In this plant the mix is being made in four 500-gallon pasteurizers and pre-heated to a homogenizing temperature of 145 degrees. From the mix vats it is pumped by two 400-gallon homogenizers directly to the Vacreator, where it is pasteurized at 200 degrees and then discharged to two cabinet coolers. These coolers, which were originally designed to handle mix at a temperature of 160 degrees, are now able to cool the colder mix coming from the Vacreator to approximately 32 degrees.

"Under the new method the mix coming from the Vacreator at 110 degrees on to the water section of the coolers with 60 degree water, goes to the direct expansion section of the coolers at approximately 68 degrees and is reduced to 32 degrees or a 36 degree drop. Based on 9,000 pounds per hour this 10 degree temperature difference accounts for approximately 7-1/2 tons of refrigeration per hour which is being done by the condenser water, relieving the compressors of this much load."

In conclusion, you will, by this time, have realized that the making of ice cream mix, with a Vacreator in the line for high-temperature-quick-time pasteurizing, gives a simple, continuous and highly effective time saving method. The procedure is merely this: The mix ingredients are placed in a mix vat and heated to, preferably, 145 degrees F. When this temperature is reached the mix commences to be fed through the homogenizer which delivers the mix to the Vacreator - wherein the pasteurizing temperature is best maintained at 200 degrees F. - which in turn delivers the now pasteurized mix to the cooler at a discharge temperature, usually, somewhere between 110 - 115 degrees F. Thence from the cooler to the storage tank as usual. It is just as easy as that. Once the flow of mix starts through the Vacreator - in which the flow time is only from 10 to 15 seconds - and the operator has made final adjustments, the machine continues to function automatically. Vat after vat of mix can be fed to the Vacreator, thus making a day's run continuous with no break. Should a break occur between vats the Vacreator is not affected. A Safety Thermal Limit Recorder is wired to the in-feed pump so that, in the event the pasteurizing temperature should fall below a required minimum point, at which the recorder automatic cut out is set, the feed of mix to the Vacreator is automatically immediately arrested.

On a recent occasion when two English ice cream company executives were visiting Oregon State College, to observe the making of ice cream from vacreated mix prepared from water, non-fat-dry-milk-solids, butter, sugar and stabilizer, they proclaimed both MIX AND ICE CREAM FLAVOR MAGNIFICENT.

STEAM DISTILLATION

G. A. Richardson

Distillation processes have been expanded and perfected to such an extent that their range of industrial application now extends beyond earlier expectations. Substances and compounds hitherto regarded as non-distillable (that is, non-volatile) are now being distilled. The dairy industry utilizes several of these processes.

1. Direct distillation: Where heating is not destructive or detrimental to the product, boiling, and condensing the vapors serves to concentrate the product and remove volatile material. In the case of the steam boiler, the vapor (steam) is freed from the mineral contents in the feed water. When pure steam is required, it is important that the feed water be free from objectionable volatile substances. For example, when chlorinated water is used as feed water, provision must be made for the removal of the combined chlorine residuals prior to feeding to the boiler.

2. Vacuum distillation: Since a liquid boils when the atmospheric pressure becomes equal to the vapor pressure of the liquid, and since the vapor pressure increases with increasing temperatures, it follows that distillation proceeds at lower temperatures with decreases in atmospheric pressures. It is obvious that milk may be condensed at temperatures that cause less change in the heat - labile components - when the water (and other volatile constituents) are distilled off at pressures lower than atmospheric.

Molecular distillation employs a very high vacuum and provision is made for holding the product being distilled at the distilling temperature a minimum of time and in very thin films. The condenser surface is as close to the distilling surface as is practicable. Use is made of these stills for the separation of Vitamin A and Vitamin E from their oil solutions, and for the fractionation of oils, including butter oil.

3. Steam distillation: The chemist, particularly the organic chemist, makes use of steam distillation to remove volatile impurities from acqueous solutions even though the vapor pressures of the impurities may be, and usually are, comparatively small. This form of distillation is possible largely because of the small molecular weight of water. The requisite for its use is that the product being distilled (distilland) is not decomposed or harmed by the steam. Steam distillation under reduced pressure affords considerable protection to the distilland.

The apparatus for demonstrating this type of distillation in the laboratory is relatively simple: A flask (round bottom if vacuum is to be employed) to serve as a steam generator; a second round-bottom flask (long neck) to hold the distilland; a condenser, and a receiving flask for the distillate. These are assembled by means of connecting tubes and appropriate traps. The steam is admitted below the surface of the distilland, preferably through a perforated disc or bulb. Provision is made to supply heat to the second flask to maintain temperature conditions for keeping the volume of distilland more or less constant. If vacuum is to be applied, additional devices are inserted to control both temperature and pressure. Valves for the release of vacuum are essential.

Dairy chemists have utilized steam distillation to determine (1) the volatile acids, such as formic and lactic, produced in milk and cream heated or sterilized at various temperatures (2) the volatile acids of rancid milk, cream, and butter (3) the volatile acidity developed in cheese during ripening. This should not be interpreted as indicating the use of steam distillation to remove the volatile acids from rancid cream. In the demonstration accompanying this discussion, rancid cream was steam distilled for twenty minutes. The distillate on being titrated with alkali showed no evidence of any acid having distilled over. To effect their distillation it is necessary to acidify the distilland with a mineral acid (sulfuric) to a PH of from 1.5 to 2.0.

Steam distillation is also used to determine the concentration of diacetyl - the compound responsible for the flavor and aroma of ripened cream. The starter distillate of commerce is a product of steam distillation. A demonstration illustrated this process. This is of little or no great practical significance inasmuch as this desirable flavor is developed in churning cream by the addition of starter to the pasteurized cream.

The third demonstration accompanying this discussion illustrated the usefulness of steam distillation for removing undesirable flavors and odors from cream. The distilland was a cream having an obnoxious feed flavor arising from green alfalfa and garlic. The flavor distilled over and appeared in the distillate. Although the process was not carried to completion, the flavor of the cream was improved considerably. It should be mentioned that differences seem to exist between the optimum conditions of temperature and pressure for effective removal of individual weed and feed flavors.

Bacteria produce a wide variety of flavors and odors in milk and cream. Some of these are not unpleasant in themselves but later become very objectionable. Although the chemistry of these substances is not completely understood, it is known that many of them are volatile and steam distillable.

Steam distillation, especially when used in conjunction with controlled pressure, temperature and rate appears to have been proved to be a valuable process in the production of quality dairy products.

SHORT COURSE IN VACREATION

VACREATION OF MILK FOR CHEDDAR CHEESE

Early Experiments - Commercial Pioneers

F. S. Board

The first experimental work done in the application of the vacreation process to the treatment of milk, used in the manufacture of Cheddar Cheese, was initiated at the Matamata cheese factory, Auckland Province, New Zealand, in November, 1934. This experimental period was terminated during March, 1935. The studies were made by B. Barnes, the plant manager, and F. S. Board.

The purpose of the trials was to study the effect of vacreation treatment of the milk in a general way, as to: effect on flavor of the milk and the cheese, green and matured; effect on setting up (coagulation); behavior of the curd during cooking, cheddaring, draining;

and to observe the cheese from its green state right on through maturing. The effects of vacreation on the composition of the whey, and yield were also to be noted. All grading was done by the New Zealand Government graders stationed at Auckland. It was hoped that vacreation might result in minimizing the bad defect of "slit openness." Vacreating temperatures were used over the range of 150 degrees to 200 degrees F.

The work proved: That a satisfactory cheese of improved flavor, having a tendency to mature more quickly, could be made from vacreated milk. The vacreated cheese usually graded higher than the daily run of the plant. An improvement in the flavor of the vacreated milk was always noted and this carried through and was maintained in the finished cheese. With only slight changes in the manufacturing procedure the curd developed and behaved normally in the vat. Analysis of the whey always gave a lower total solids content, than the plant run, and therefore a greater yield of cheese.

In May, 1935, some preliminary work was done at Massey Agricultural College, New Zealand, in comparing cheese, made from the same milk, from normally pasteurized and vacreated milk. This work disclosed that whereas the control cheese had a poor flavor with not so good a body, the vacreated milk cheese had superior body with - as described by the Government graders, "flavour clean and good."

The next work to be undertaken was when Dr. G. H. Wilster, R. E. Stout and F. S. Board made a number of study runs at Oregon State College, Corvallis, Oregon, in 1939, following the installation of the Vacreator there in October, 1938. It was found that generally the results were good, and extremely so as to flavour. Occasionally, however, a lipase induced flavour developed, which, somehow, at times, survived the pasteurizing temperature used in the Vacreator.

Similar preliminary experiments were also made at Iowa State College by Dr. N. E. Fabricius and V. H. Nielsen. Here, too, good results were obtained excepting when, in some of the runs, the lipase was not inactivated. Fabricius and Board subsequently found that the enzyme lipase survived 2½ minutes in the Vacreator at 162 degrees F. (Less change takes place in the milk constituents in the Vacreator, than with other forms of pasteurization at comparable temperatures.) It was subsequently found that lipase is inactivated at a vacreating temperature of 175 degrees F. and above, with no preheating of the milk.

During 1940 G. H. Wilster and R. P. Robichaux worked on the problem of lipase inactivation and developed a combination process of atmospheric preheating at a minimum temperature of 145 degrees F. followed by vacreation at 165 degrees F. minimum. The details of this work and results obtained are contained in a paper given at the Annual Meeting of the American Dairy Science Association, Portland, Oregon, October 5, 1941.

It was found that a cheese of higher grade could be made when the milk was pre-heated and vacreated, at these temperatures, when compared with the control samples made from raw milk. Quoting from the report, referred to above, the excellent results obtained are described by Wilster and Robichaux thus:

"The twelve split batches of cheese were scored by a Federal grader at Portland on September 16th. The cheese at that time ranged in age from 2 weeks to 2 months old. The grader scored each lot of cheese separately and with no previous knowledge of the identity of the samples or the methods used in the manufacture of the cheese.

The scores of the raw milk cheese ranged from 88 to 91, and averaged 89.87. The scores of the vacreated cheese ranged from 89.5 to 92 and averaged 90.92.

The following frequency distribution of the scores placed on the cheese shows that 6 lots or 50 per cent of the vacreated milk samples scored higher than 91, whereas none of the raw milk samples received scores that high. On the other hand 4 samples of 33 1/3 per cent of the raw milk samples received scores lower than 90, whereas only 2 samples or 15 per cent of the vacreated samples received scores below 90.

Of the 12 split batches of cheese made from the same milk, 11 of the samples coring highest were made from vacreated milk whereas only 1 sample of the raw milk cheese scored higher than the vacreated-milk cheese. The vacreated milk cheese scored an average of 1.05 points higher than the raw milk cheese."

The first commercial cheese plant installation was made in August, 1943, when the Rutherford Co-op County Creamery, Murfreesboro, Tennessee, installed an "M" type machine for pasteurizing the cheese milk. In spring and autumn the milk supply in this district is heavily tainted with wild onion flavour which is carried through into the cheese and constitutes serious blemish and causes heavy financial loss. It was mainly to rid the cheese milk of this obnoxious flavour that this company decided to install the Vacreator. The Wilster-Robichaux method of combined atmospheric pre-heating at 145 degrees F. and vacreation at 165 degrees - 170 degrees F. was followed. Immediate results on cheese quality were so good that the company at once decided not only to vacreate the onion tainted milk but to use the Vacreator to pasteurize all cheese milk, thenceforward, as standard practice. This has been followed and obtains today at that plant to everyone's entire satisfaction. (See Cherry-Burrell Circle Sept.-Oct., 1945, p. 7 - The South's Largest Co-operative Creamery.)

Follwoing the installation of the Vacreator in the cheese plant at Murfreesboro, Tennessee, Mr. H. L. Wilson, then Senior Marketing Specialist, Dairy Products Division, War Food Administration, Washington, D.C., conducted a practical cheese making class and demonstration at the Rutherford Co-op County Creamery. In the attendance was Mr. J. E. Jones, manager of the Hopkinsville, Kentucky, cheese plant of Borden Company. Mr. Jones was also plagued with onion flavoured milk in his Kentucky plant and was quick to appreciate the overall advantages that could accrue from the use of a Vacreator in his cheesemaking operations. So, in September, 1944, one was installed in this Borden Company plant. For some years it operated with a continuous internal tube pre-heater and open type surface cooler. Recently a Superplate was installed to pre-heat the milk on its way to the Vacreator and to cool the milk on its way to the cheese vats. Some regeneration value is had with this set-up. The Vacreator is equipped with Recorder steam control and automatic pump stop. Manager Jones is emphatic regarding the advantages gained from the Vacreation of cheese milk and is responsible for the following:

"After the Vacreator was installed a careful check of the milk was made after pasteurization to determine if any feed or weed flavors could be detected in the pasteurized milk. It was impossible to detect any off-flavors in the pasteurized milk. There was a marked improvement in the quality of the cheese produced from vacreated milk. In fact, a large receiver of Borden's cheese stated that it is his belief that the Borden factory at Hopkinsville is producing the finest cheese made in Kentucky.

It has been found that the Vacreator has improved the yield of the cheese. Moisture is more readily controlled and the finished cheese ripens more rapidly than the cheese produced before the Vacreator was installed. The body of the cheese has also shown definite improvement. To sum up the results of operations to date, the Vacreator has accomplished all that was expected of it.. Everyone connected with the Hopkinsville plant is well pleased with what has been accomplished." (See Cherry-Burrell Circle May-June, 1945, p. 29, Vacreator Improves Quality of Cheese in Kentucky Factory.)

The next pioneer installation was that made by the Bedford Cheese Company, Shelbyville, Tennessee, when an "M" type machine was put into operation in that company's cheese plant in the Fall of 1945. The owners, Messrs. Lyons and Siewert, were confronted with having to produce cream and cheese from milk tainted more heavily with onion flavor than any the author has yet encountered. In order to step up the steam distillation intensity sufficiently to completely remove the onion flavor, and at the same time maintain a high capacity, the efficiency of the ejector-condensers was increased by enlarging the bore of the nozzles from 25/64" to 27/64" diameter. At Shelbyville general all-around improvement in quality of both cream, cheese and whey-cream resulted. The total solids content of the whey decreased. Considerably higher returns were received and the installation investment was recovered within a few months from increased values of the products made. H. E. Behlmer and F. S. Board spent several days at this plant in April, 1946, making check runs and the data sheet, annexed to this paper, gives an interesting log of a Vacreator operation on onion tainted milk.

Fourth to assume the rank of pioneer was the Alabama Dairy Products Company where, under the progressive management of C. Jarvis, an "M" type Vacreator was put to work, pasteurizing milk for Cheddar cheese, in a big way, in March, 1948. This plant was equipped with a Superplate pasteurizer but that alone did not suffice, so a Vacreator was incorporated in the line so as to do a maximum pasteurizing job. Here both the Superplate and Vacreator are equipped with control mechanism which ensures that no milk can pass from the plate pre-heater into the Vacreator at a temperature below 145 degrees F. and that no milk can find its way through the Vacreator unless it has reached to at least 170 degrees F. Some onion tainted milk is received during Spring and Autumn, but this fact alone was not the deciding factor, in this case, when it came to ordering a Vacreator. The overall advantages to be gained from vacreating cheese milk were fully appreciated and the manager's recent report indicates that these are being fully realized. According to this advice the cheese is showing a greatly improved and uniform flavor and the cream, obtained from standardization of the milk, is obtaining in the market from 10¢ to 20¢ per pound more than would, otherwise, be realized.

Of the managers of these first plants to use the Vacreator for the pasteurization of cheese milk - Bernink of Murfreesboro, Tennessee; Jones of Hopkinsville, Kentucky; Lyons and Siewart of Shelbyville, Tennessee; and Jarvis of Decatur, Alabama; it can be truly said that " a pioneer is one who sees where the rest are going and gets there first."

From the proper use of the Vacreator in a Cheddar cheese operation, the following may be expected:

1. Satisfactory pasteurization of the milk.
2. A negative phosphatose.
3. Removal of feed, weed and certain fermentation flavors.
4. Unmasking of the natural flavor of the milk.
5. Lesser change in the delicate milk constituents, at comparable temperatures, which are important in manufacture and maturing of the cheese.
6. Removal of oxygen and carbon dioxide from the milk which aids in uniform development of acid during the making process.
7. Cheese making process becomes more regular and standardized.
8. The flavor of the cheese and its general quality becomes more uniform.
9. The cheese matures faster.
10. Less total solids in whey - higher yield.

The Vacreator, being of continuous operation, with its final cooling stage, fits ideally into the normal cheese-making operation.

For pre-heating, a continuous type heater, such as a plate heater and cooler, Box-Tube heater, or internal tube heater is recommended. A plate heater and cooler is preferred, however, as it combines pre-heating before vacreation and the cooling necessary after vacreation in one piece of equipment.

Operation: Pre-heat the milk continuously to 145 degrees F. The pre-heating temperature must not fall below 145 degrees F. Feed directly from the pre-heater to the Vacreator. Pasteurize at between 170 degrees and 175 degrees F. using whatever treatment intensity may be found necessary to give the desired improvement in flavor.

In order to maintain the pasteurizing temperature at as low as 170 degrees F. and still have sufficient treatment intensity, it is recommended that the equilibrium valve float ball be removed from the machine and the temperature regulated by the steam valve. Unless weed flavors in the milk are very intense the Vacreator can usually be operated at its full rated capacity.

Discharge the milk from the Vacreator to the milk cooler and cool to the desired setting temperature.

There need be no significant alteration of the cheese making process. Vats will usually run closer to one standard because of better pasteurization and the removal of air from the milk. The cheese will mature in shorter time, will be much cleaner in flavor and there should be a slightly higher yield. The cream derived from standardizing the vacreated milk will be much cleaner in flavor and therefore of greater value. This also applies to the whey-cream.

SHORT COURSE IN VACREATION

VACREATION OF MARKET CREAM

F. S. Board

Dr. N. E. Fabricius, at that time Associate Professor in Dairy Manufacturing at Iowa State College, Ames, Iowa, was the first to initiate experimental studies in the use of the Vacreator for pasteurizing market cream. This preliminary work was done at Iowa State College in late 1940 and in a letter to the author dated January 7, 1941, Dr. Fabricius reported, inter alia:

Market Cream

1. No trouble with cream plug.
2. No feathering.
3. Flavor greatly improved.
4. Keeping quality greatly improved with respect to oxidized flavor.
5. Reduced viscosity.

Whipping Cream

1. Overrun just as high.
2. Slightly shorter whipping time.
3. Slightly less drainage from the whipped cream.
4. Reduced viscosity.
5. "In all other respects it is very satisfactory."

According to Fabricius, then, it was disclosed that vacreation of market cream (a term inclusive of straight table cream, whipping cream, coffee cream or cream that may be used in the manufacture of ice cream) would be entirely satisfactory but that a reduction of viscosity could be expected. Some reduction of viscosity in cream and ice cream mix seems to be inherent in the vacreation process and in some cases may be considered a drawback where cream is intended for bottling and general table use. Vacreation has, however, many outstanding advantages as a method for pasteurizing cream.

In the early summer of 1946 a large market cream plant in the Middle West commenced using an "M" type Vacreator for the purpose of pasteurizing their product. This company had understood that some loss of viscosity of the cream might occur but reasoned that this would not affect the important advantages to be gained from better pasteurization, flavor improvement and increased keeping quality. This plant handles as much as 40,000 pounds of market cream daily in the flush season and is putting out an excellent product.

In the territory of the Cherry-Burrell Baltimore branch there are several plants, equipped with BABY and JUNIOR machines, regularly vacreating market cream and have been so doing, in most cases, for a number of years. One of these, recently reporting on the vacreation of the milk, prior to separation, had this to say:

"Part of our supply of milk comes from Delaware. Much of this supply is garlic for three or four weeks in the Spring and sometimes for a short period in the Fall. All garlic milk we pasteurize with the Vacreator. Using a temperature of 196 degrees to 198 degrees. The milk so pasteurized is free from all odor and taste. This milk we separate. The cream is sold as fluid cream or used for any other purpose. The skim is used in cottage cheese, buttermilk or chocolate drink."

In order to turn out a good vacreated product care must be exercised to ensure that the cream is derived from good clean fresh milk. The separating temperature is important and should be constant and not unduly high. 85 degrees F. is a satisfactory separating temperature. If the cream is not to be standardized and vacreated shortly after separation it would be cooled as it leaves the separator and later pre-heated to 110 degrees - 115 degrees F., standardized and then vacreated, using a pasteurizing temperature of 200 degrees F. on the Vacreator. If cream is to be standardized and vacreated as separated, it should be accumulated in a coil vat, spray vat or round processor wherein it is heated to a temperature of 140 degrees F. while the vat is filling. This is done to avoid deterioration of the cream by bacterial development while the vat is being filled and standardized. The separating temperature of 85 degrees F. would not be a desirable temperature at which to hold cream for any length of time. The Vacreator will discharge the cream to the cooler where its temperature should be brought down to under 40 degrees F.

Should it be desired to increase the viscosity of vacreated cream, this might be done by pumping the vacreated cream through a spring loaded valve on its way to the cooler. In studies made by Dr. C. W. England and the author, during September, 1947, on the whipability of vacreated market cream, of which the viscosity had been increased by such means, it was found: (1) that the cream had excellent whipping qualities, (2) that there was little, if any, drainage after 24 hours, (3) feathering tests of the same cream before whipping were quite satisfactory.

It is very important that the Vacreator, where used for pasteurizing market cream, should be equipped with a Safety Thermal Limit Recorder wired as pump stop control. This instrument is set to automatically arrest the forward flow of the cream to the Vacreator should the pasteurizing temperature drop to some given minimum.

CONDENSING WITH THE VACREATOR

by

G. H. Wilster

We are living in the Atomic Age. Not only have we seen the development of the Atom bomb but there has been thousands of inventions from "faster than sound" jet airplanes to ball-point pens and from frozen "ready-to-bake" pies to rindless "natural" cheese.

Developments in the field of dairy technology and manufacturing have not been startling but even during the three years since the end of World War II there have been hundreds of developments. One of these, that had its birth during the war, is condensing milk, ice cream mix and other fluid products with the Vacreator. Yes! why not? you will say. It ought to be as simple as "falling off a log" as a nearly perfect vacuum is maintained in the Vacreator during vacreation. Yes, the process is simple but it was not so simple when we first experimented with this method. Quite a number of gallons of skim milk went into the sewer before the method was perfected. It is said that necessity is the mother of invention. Because of the shortage of dry milk during the war, the Oregon State College Dairy Products Laboratory was severely handicapped in its ice cream operations. Conservation order DA-1 made mandatory the setting aside for governmental and military use of at least 90 percent spray process non-fat dry milk solids manufactured beginning November 5, 1942.

The problem resolved itself into a choice of whether the milk needed to supply the extra nonfat solids should first be condensed alone in the Vacreator or the entire ice cream mix should be prepared and then condensed to the desired composition.

The following two procedures were outlined:

1. Place sufficient skim milk, or whole milk, required to supply the necessary amount of solids, in addition to the solids supplied by the cream, in a vat and circulate this through a preheater and the Vacreator until the desired concentration is reached. Then add the other ingredients required for the mix, homogenize, and pasteurize (vacreate).
2. Prepare the mix by using combinations of the necessary amounts of cream, butter, whole milk or skim milk to supply the desired amounts of fat and milk solids-not-fat, as well as the other necessary ingredients. Circulate this mixture through the preheater and Vacreator until a sufficient amount of water is removed to give the mix the correct percentage composition. Follow this by homogenization and vacuum pasteurization of the mix.

In trial 1, cold skim milk was placed in a coil vat. With the machine assembled and operating as for cream pasteurization, except with no steam entering the first (pasteurizing) chamber, the skim milk, pre-heated in the vat to 150 degrees F., was fed to the machine. Although the vacuum gauge on the third chamber showed 28 inches vacuum, no milk could be obtained from the machine; it mixed with the water in the condenser unit and was discharged into the drain. When steam was added to increase the temperature of the milk in the first chamber to between 160 degrees to 170 degrees F., however, and with the ball in the equilibrium valve removed, the milk reached the boiling stage as during ordinary vacreation, and passed through the apparatus but still with considerable loss into the condenser. Circulating the milk in this manner for several hours resulted in slightly increasing the density of the milk.

Although it must be conceded that the experiment was almost a failure, it did indicate that it was possible to effect some concentration of the milk. The solids of the milk were increased from about 9 percent to 11.3 percent.

In trial 2, 350 pounds of skim milk were placed in the coil vat. With the lids kept open the milk was heated to 150 degrees F. The milk was circulated through the Vacreator at a rate of 2,000 pounds per hour. With the coil in the vat revolving continuously and the milk maintained at a temperature that ranged from 143 degrees to 175 degrees F., and enough steam added to the milk in the first chamber of the machine to maintain a temperature of approximately 170 degrees F., it was possible to concentrate the milk to some extent over a period of 1 3/4 hours. The Baume reading at the end of the run was 12.8, which corresponds to a total solids content of 24.3 percent. The concentration was: $\frac{24.3}{9} = 2.7$, or 2.7 to 1.

It was concluded that:

1. The time required for condensing was excessive.
2. Too much steam and water were required.
3. Too much milk adhered to the coil, making cleaning difficult and also causing a loss of milk solids.

In order to speed up the process and avoid collecting milk solids on the vat coil it was decided to employ, in trial 3, a small vertical flash heater for the heating of the milk prior to its entrance to the Vacreator. This was installed between the coil vat and the Vacreator.

For this trial 600 pounds of skim milk were used. The temperature of the milk was maintained at 120 degrees F. in the coil vat. The rate of flow of milk was 2,000 pounds per hour through the flash heater and Vacreator. The heating temperature averaged 192 degrees F. and the temperature of the milk as it emerged from the Vacreator ranged from 105 degrees to 115 degrees F. No steam was used with the Vacreator. The pressure in the second chamber was maintained at from 24 to 25 inches vacuum, and in the third chamber at from 27 to 28 inches vacuum.

After $2\frac{1}{2}$ hours of circulating the milk the Baume reading of the condensed milk was 16, which corresponds to a total solids content of 30.3 percent. This was a concentration of 3.4 to 1. The flavor and physical appearance of the condensed milk were satisfactory. The milk was used for the manufacture of ice cream.

Trial 5 was a repetition of trial 4. Using 500 pounds of skim milk in $2\frac{1}{2}$ hours the condensed milk had a Baume reading of 17.2. This corresponded to a total solids content of 32.6 percent. Difficulty was still experienced with some loss of milk as a result of excessive foaming in the Vacreator.

In trial 6, 1,000 pounds of skim milk were used. The milk was heated in the flash heater to approximately 200 degrees F. No steam was used in the Vacreator.

In three hours the milk had been concentrated to give a Baume reading of 17.2. This corresponds to a total solids content of 32.6 The concentration was 3.6 to 1.

Summary of Trials Involving Condensing Milk

The experimental work so far had shown that:

1. Using the Vacreator for condensing skim milk was feasible,
2. Condensed skim milk of desirable properties was obtained.
3. The method appeared practical,

Following the preliminary trials of condensed milk, and certain other trials on condensing ice cream mix, it was decided that the most desirable procedure, for both practical and economic reasons, would be -

first to condense the milk and then add the other mix ingredients prior to homogenizing and vacreating.

For the purpose of the next series of trials it was thought best again to use skim milk in preference to whole milk. Certain aspects of the condensing phase remained to be perfected. The checking of the proportioning of the mix composition would be less complicated.

The plan involved the placing of a sufficient amount of skim milk, to be subsequently used in ice cream mix, in the coil vat to furnish the necessary amount of milk solids-not-fat in addition to the skim milk was then condensed to the desired concentration.

The problem was as follows:

a. Determine the exact Baume reading for the finished condensed skim milk.

b. Eliminate loss of skim milk during condensing.

c. Speed up the condensing process.

Some difficulty was being experienced with a loss of milk in the condensing water. This was finally overcome by avoiding a too high vacuum in the second chamber. In the case of such entrainment this, it was found, could be rectified by increasing the pressure in the chamber by adjusting the snifter valve, thus decreasing the vacuum and increasing the boiling point. It was also necessary to maintain at least a difference of 3 to 4 inches in the vacuums of the second and third chambers. The ideal vacuums appeared to be approximately 24 inches in the second chamber and 27½ to 28 inches in the third chamber. The difficulty could also be overcome by temporarily reducing the rate of inflow of milk and by turning a little steam into the first chamber.

Increasing the Rate of Condensing

In order to speed up the condensing process it was decided to:

a. Maintain the temperature of the skim milk in the coil vat at

140 degrees to 150 degrees F. during condensing.

b. Heat the skim milk to approximately 205 degrees F. before it enters the Vacreator.

c. Circulate the milk through the Vacreator at a rate of 5,000 to 7,000 pounds or more per hour.

The procedure followed when condensing skim milk was to place the skim milk, required for each 900-pound batch of finished ice cream mix, in the coil vat and condense this until the desired solids-not-fat content was reached. The other ingredients were then added to the condensed milk in the vat and the mixture heated, homogenized, vacuum pasteurized, and cooled.

It has been possible to step up the water-evaporating capacity of the Vacreator from 300 to 500 pounds of water per hour. This was done by increasing the flow of milk through the flash heater and by operating the Vacreator as outlined above. No steam was used in the Vacreator and no water was used in either of the chamber jackets.

The time for condensing the skim milk to the concentration desired was reduced to 45 minutes for a 900-pound batch of mix. The final Baume reading of the condensed milk as recorded was made at 60 degrees F.

The flavor, color and general appearance of the condensed milk made have been entirely satisfactory. The milk has been remarkably free from a cooked flavor. Various members of the Dairy Department have pronounced the quality of the milk excellent. They have been unable to detect any trace of undesirable flavor in the milk.

The maximum amount of water evaporated from skim milk, when the Vacreator was used as a milk condenser, under the conditions of this research, was found to be 500 pounds per hour, or 8 1/3 pounds per minute.

The rated cream pasteurizing capacities of the three different-sized Vacreators are: 2,500, 5,000 and 12,000 (15,000 milk) pounds per hour respectively. The water evaporating capacities of the larger-sized pasteurizers, with the capacities of the larger models calculated on the basis of the evaporating capacity per hour from skim milk of the small machine and on the different pasteurizing capacities, would be: 1,000 pounds and 3,000 pounds respectively. The water evaporation with the experiment station machine would be considered very satisfactory performance when compared with a small-sized standard milk-condensing vacuum pan.

The water evaporating capacities of different-sized vacuum pans are approximately as follows:

Diameter of pan	Water Evaporation per hour
28 inches	450 to 600
36 inches	1,100 to 1,400
42 inches	2,000 to 2,600
48 inches	3,000 to 4,000

The range in temperature of the water used for the ejector condenser of the Vacreator employed in these experiments was from 47 degrees to 63 degrees F. The water pressure used, when pasteurizing the mix with the Vacreator, varied from 55 to 75 pounds per square inch but when the machine was used as a milk condenser the pressure was raised to 105 pounds per square inch. This was accomplished by regulation of a bypass valve fitted on the water pressure pump. When, during pasteurization of the mix, the pressures ranged from 55 to 75 pounds per square inch the water consumption was from 8,500 pounds to 10,000 pounds per hour. During the condensing process, when the water pressure was raised to 105 pounds per square inch, the water consumption was increased to 12,000 pounds per hour.

Assuming that two-thirds of the water evaporated from the milk is removed in the second chamber at a boiling point of 140 degrees F. and one-third is removed in the third chamber at a boiling point of 111 degrees F., the theoretical amount of 60 degrees F. water necessary to condense the vapor, when there is a 35 degree F. increase in water temperature, would be:

Heat content of water vapor at 140 degrees F.:
$1 \times 2/3 \times 1{,}121 = 747$ btu.
Heat content of water vapor at 111 degrees F.:
$1 \times 1/3 \times 1{,}108 = 369$ btu.
Total heat content of 1 pound vapor from Vacreator =
$747 + 369 = 1{,}116$ btu.

One pound of condensing water at 95 degrees F. contains a total of $(60 + 35) - 32 = 63$ Btu.

The net heat to remove from 1 pound of water vapor from the milk is: $1{,}116 - 63 = 1{,}053$ Btu.

To condense 1 pound vapor from the milk, with water entering the condenser at 60 degrees F. and leaving at 95 degrees F., there would be required: $\frac{1{,}053}{35} = 30.0$ pounds of water

For 500 pounds vapor there would be required $30.0 \times 500 = 15{,}000$ pounds of water.

It should be possible to obtain satisfactory performance by using a smaller amount of water. This would mean that there will be more heat units removed per pound of water.

If the water enters the condenser at 60 degrees F. and leaves at 110 degrees F. the rise in temperature is: $110 - 60 = 50$ degrees F. The pounds water required would be: $\frac{1{,}053}{50} = 21.06$ pounds for 1 pound of vapor or 10,530 pounds of water for 500 pounds of vapor.

With a 60 degree rise in the condenser water temperature a total of only 8,775 pounds of water would be necessary to condense 500 pounds vapor. This latter figure compares closely with that given by Hunziker*

* O. F. Hunziker, Condensed Milk and Milk Powder, 5th ed., 1935. Published by the author, LaGrange, Illinois

as the theoretical requirement.

It would appear, therefore, that when water at a temperature of 60 degrees F. is used for the ejector condenser there is an ample margin of condenser water available when the total amount of water used is 12,000 pounds.** The colder the water used the less will be required when the temperature of the outgoing condenser water remains constant.

After having successfully employed the Experiment Station Vacreator for the dual purpose of condensing skim milk and pasteurizing ice cream mix it was desired to make some tests under commercial conditions. No Vacreators were in use in Oregon or in other western states, so far as was known, for vacreating ice cream mix. It was known that a "Junior" size Vacreator had been used by I. N. Hagan Ice Cream Company, Uniontown, Pennsylvania, for several years. This was the first commercial ice cream factory in the United States to vacreate ice cream mix.

To summarize the research conducted on the commercial conditions it can be stated:

1. Condensing skim milk to the concentration desired for use in ice cream mix was found practicable, under commercial conditions, using a "Junior" Vacreator. The amount of water removed per hour from the milk approximated 1,000 pounds.

2. When whole milk was condensed with the "Junior" Vacreator to the concentration desired for ice cream mix, it was found possible to remove approximately 800 pounds of water from the milk in 1 hour.

3. The process, especially when whole milk was condensed, was simple and convenient, and fitted in well with the subsequent mixing, homogenizing, and vacreating of ice cream mix.

4. Ice cream was made and hardened the same day the milk was delivered to the ice cream factory.

** The water used need not be wasted. It can be cooled by spraying on a tower and used again.

5. The bacterial content of the condensed milk and of the vacreated mix was low.

6. The phosphatase test on the condensed milk and vacreated mix was negative.

7. The ice cream manufactured was of excellent quality. That made from a mix in which condensed whole milk was used was superior in quality to that made from a mix in which condensed skim milk was used.

8. The mix possessed a superior freezing quality and the ice cream had a finer flavor than that previously made, in accordance with the judgment of those in charge of the I. N. Hagan Ice Cream Factory.

As the method of preparing ice cream mix using condensed whole milk may find considerable application in the plants that have Vacreators a practical, simple method for calculating a mix has been presented in Oregon State Agricultural Experiment Station Bulletin No. 430 entitled "The Dual Use of the Vacreator for Condensing Milk and Pasteurizing Ice Cream Mix." In the bulletin is also given full directions for determining the density of the condensed skim milk by the use of the Baume hydrometer and for calculating the percent solids in the skim milk.

Two engineers in the Department of Mechanical Engineering at Oregon State College, Professors W. C. Baker and C. J. Arents, determined the cost of condensing milk with the "Baby" Vacreator at Corvallis.

The cost of the water used for condensing under the conditions of the experiment was 14 cents for the milk for a 900 pound mix and the cost of electricity was 6 cents. The total cost of steam, water and electricity for condensing the milk for a 900 pound mix containing 10 percent milk solids - non-fat was 57 + 14 + 6 = 77 cents.

The cost can undoubtedly be reduced. The milk heater operated was of insufficient capacity and for that reason was inefficient. The amount of water used was greater than was theoretically necessary, while the electric power consumption could be reduced if a tubular milk heater, instead of the centrifugal heater, was used.

In the Experiment Station Bulletin referred to it is shown that under the market conditions, as existed in 1944, it was possible to effect a saving of $2.94 on each 1000 pounds mix when using the condensing method with the Vacreator as compared with the use of dry milk.

In addition to the savings effected by condensing and the beneficial effect on the quality of the ice cream, there are a number of other advantages in using the Vacreator as a milk condenser. It is possible to utilize a larger amount of locally produced milk; pasteurized condensed milk can be sold to other ice cream factories, to bakeries, and candy manufacturers; sweet buttermilk can be condensed; sweetened condensed milk can be made and stored for future use; the method may be useful when manufacturing mix containing a high percentage of solids and also in connection with the manufacture of certain dehydrated dairy products. If sweet cream is unobtainable, as during the peak ice cream producing season, unsalted sweet cream butter and condensed skim milk or whole milk can be successfully used for ice cream mix.

The present research did not include studies having for their purpose the development of the method as a "continuous" process. It is believed feasible to modify the present developed method in such a way that large dairy plants can continuously condense milk to the desired concentration. This may require some additional equipment, such as stainless-steel tanks and automatic density regulators.

The experiments reported on have shown that skim milk and whole milk can be condensed to the desired concentration for use in ice cream mix by the use of a Vacreator. The process as developed by the Oregon Agricultural Experiment Station is simple and practical. Assuming that a Vacreator is already available for pasteurizing the mix, as the final step in its preparation, the only additional equipment necessary for the condensing process would be a suitable continuous-type heater and a pump. The condensing process requires a relatively short time and is easily controlled. Only little supervision is necessary during condensing. The density of the condensed milk may be easily and reliably determined by means of a Baume hydrometer or a pycnometer. The fact that only a relatively small amount of milk is present in the Vacreator when condensing -- 30 pounds in the "Baby machine -- and the milk passes through the machine at the rapid rate of about 1.5 to 1.9 pounds per second explains the efficiency of the machine in removing vapor from the boiling milk. The temperature of the milk during the brief time it is exposed to the vacuum in the chambers is reduced by about 90 degrees Fahrenheit. When making mix of the same composition, from day to day, and using cream of the same fat content, the Baume reading, or weight of a given volume of condensed milk, will remain constant. Although it is not necessary to install elaborate laboratory equipment for determining, by gravimetric method, the total solids content of the condensed milk made, it is desirable for any fair-sized ice cream factory to have simple equipment for determining the total solids content of the condensed milk and of the finished mix.

The research was not conducted for the purpose of comparing the quality of ice cream made when different condensed or dehydrated milk products were used in the mix. The quality of the condensed milk prepared by the method described and the quality of the mix and ice cream made were highly satisfactory.

A study of the cost involved when skim milk was condensed with the Vacreator to the density required for use in ice cream mix indicated that this method of condensing was economical. It was also found that the cost of the milk solids made available for ice cream by this method in comparison with the outlay for milk solids in other commercial forms showed the practice developed to be profitable.

As no steam was used in the machine during condensing only a slight amount of milk solids was deposited on the inside surfaces. It was unnecessary to dismantle and clean the apparatus after the milk had been condensed and before the mix was subsequently vacreated.

CONDENSING -- VACREATION OF ICE CREAM MIX

The method of condensing the skim milk, to the desired concentration required for the ice cream mix, followed by the addition of the other mix ingredients may still be the most practicable method to use in a plant where a supply of skim milk is regularly available. But many ice cream plants would prefer to place all the necessary mix ingredients in a tank and condense the mixture rather than to go to the trouble of first separating the milk, then condensing the skim milk, and finally, adding the other mix ingredients. Furthermore, many ice cream factories do not have a separator. They purchase the necessary amount of milk and cream, either direct from the producers or from other dairy plants. In these ice cream factories, savings can be made by condensing the mixture using whole milk (or skim milk), cream, sugar, stabilizer, egg, etc. If the same Vacreator that is used for condensing is to be subsequently used for vacreating the mix there is no need of cleaning the Vacreator after condensing. The Vacreator can be used continuously by immediately homogenizing and vacreating each batch of mix following completion of the condensing operation. The Vacreator will function ultimately both as condenser and pasteurizer.

A few preliminary tests of the method of condensing the ice cream mixture with the Vacreator were made during 1943 and 1944. Pressure of other work necessitated delaying further research on the problem until during the spring of 1948. The conventional methods of calculating the amount of the different ingredients to use for the uncondensed mixture were used.

With six batches of mix, each of 100 gallons final volume, the amount of water removed from each batch of mixture was approximately 560 pounds. Approximately $1\frac{1}{2}$ hours were required to do this with the "Baby" size Vacreator, using a tubular heater for preheating the mix, before it entered the Vacreator, to a temperature of approximately 200 degrees F. The desired Baume reading was 12.06 degrees at 100 degrees F. and the readings of the finished mix averaged 12.2 degrees. With some batches, slight over-condensing took place and it was necessary after testing the mix to standardize it with a small amount of water. After condensing the temperature of the mix was adjusted to 150 degrees F. and the product was then homogenized and vacreated.

Following these preliminary tests it has become common practice, in the Dairy Laboratory at Oregon State College, to use this method of preparing ice cream mix. It is a convenient method and the resulting mix is very satisfactory.

The excess water in the mixture of milk, cream, sugar, gelatin and whole eggs for a 100-gallon mix can be removed by the "Baby" Vacreator in about $1\frac{1}{2}$ hours, or at a rate of about 375 pounds water per hour. The condensing process is stopped when the desired Baume reading was obtained. It has been found that the final mix composition, after vacreation, is very close to that desired; namely, 12.5 percent fat and 39.50 percent total solids. The vacreated mix has consistently showed negative coliform and phosphatase tests. The bacteria of vacreated mix have ranged from 10 to 300 per ml. The flavor of the mix has been excellent. A cooked flavor is avoided, and feed flavor, when present in the raw product, is eliminated by the condensing-vacreation method.

QUESTIONS AND ANSWERS ON VACREATION OF ICE CREAM MIX

1. What condition and quality of steam is required to satisfactorily operate the Vacreator?

   A. Clean, dry, saturated steam, free from superheat, and free from objectionable taste must be used.

   To deliver pure steam to the Vacreator, three precautions must be observed.

   (1) Priming of the boiler must be prevented.
   (2) A steam purifier and a steam trap should be used.
   (3) Pungent flavored boiler compounds, such as tannate, should not be used. When this product was used once in the Oregon State College Dairy Laboratory boiler, an objectionable flavor was noticed in the ice cream mix. Our engineers have successfully used starch for conditioning the sludge in place of tannate. (Causes the scale to be porous and bulky and makes it easier to remove from the boiler.)

   To prevent superheat in steam after the steam has passed from the high pressure line through a pressure reducer to the low pressure line going to the Vacreator, some uninsulated pipe should be used leading from the reducing valve to the Vacreator. The amount of bare pipe needed to desuperheat steam (remove BTU's) can be calculated by an engineer. It will vary with the original steam pressure and with the steam demand by the Vacreator. At Corvallis we have eliminated superheat in the steam and we have experienced no difficulty with cooked flavor in the ice cream mix.

2. What quantity of water is required to operate the Vacreator?

   A.

No. 3	17 to 24 gal. per minute	- 1020 to 1440 gal. per hour
No. 6	32 to 46 gal. per minute	- 1920 to 2760 gal. per hour
M	32 to 46 gal. per minute	- 1920 to 2760 gal. per hour

3. Why is the water consumption of the large Vacreator the same as with the medium size machine?

   A. The water consumption of the large "M" type Vacreator is only the same as the smaller No. 6 type Vacreator when the initial water temperature does not exceed 70 degrees F. Above this temperature the water consumption of the large machine will be doubled. With low temperature water available the two condensers on the large machine are used in series but with water exceeding 70 degrees F. these condensers must be used in tandem. Such is not the case with the smaller machines.

4. Must the water be of pure quality?

   A. Preferably, but not necessarily. As the water is used only in the ejector condenser there is no possibility of contaminating the pasteurized product. The outlet from the condenser must never be under pressure.

River water, lake water, or pond water, may be used. The water could be reused if a suitable atmospheric water cooling apparatus was used.

5. Have you noticed any unfavorable break-down of the mix attributed to Vacreation?

A. On the contrary. During the two-week period I spent at the I. N. Hagen Ice Cream Factory at Uniontown, Pennsylvania, the texture, body and melt-down quality of the ice cream made from Vacreated mix, in the opinion of those in charge of the plant, was excellent.

6. To what extent is the cooling of the mix facilitated?

A. It has been reported that in an ice cream plant located in an eastern state, the mix coming from the Vacreator at 110 degrees F. on to the water section of the coolers, using 60 degrees water, goes to the Direct Expansion section of the coolers at approximately 68 degrees F., and is there reduced to a temperature of 32 degrees F. This is a 36 degree drop. Based on 9000 pounds mix per hour, this temperature drop of 12 degrees, has resulted in a saving of approximately 7½ tons of refrigeration per hour.

In the batch method, where 165 degrees F. mix was first cooled on cabinet coolers with 60 degrees well water, it was cooled to 80 degrees and was then further lowered to 36 degrees F. on the direct expansion section--a 44 degree temperature drop.

The 12 degree difference was effected by the water and thus relieved the compressors of a considerable load.

Since 60 degree well water was used, this water was used, serially, through both of the condensors in the large size Vacreator. In this way, only 39.6 gallons of water per minute was used with the machine.

	From Vats to Cooler	Off cooler water section	On to cooler D. E. section	Off cooler D. E. section
BEFORE	165 degrees	80 degrees	80 degrees	36 degrees
	From Vacreator to Cooler			
AFTER	110 degrees	68 degrees	68 degrees	32 degrees
DIF.	55 degrees	12 degrees	12 degrees	4 degrees

The Vacreator having reduced the mix to 110 degrees F. eases the load on the cooler water section which delivers the mix to the D. E. section at 12 degrees F. lower temperature. The load on the D. E. section is, therefore, lessened resulting in a lower final mix temperature and a saving of $7\frac{1}{2}$ tons refrigeration per hour. The somewhat lower viscosity of the mix also contributes to better cooler performance.

7. Can you explain in a little more detail, the cooling of ice cream mix in this plant?

   A. In this plant the mix is being made in four 500-gallon pasteurizers and preheated to a homogenizing temperature of 145 degrees F. From the mix vats, it is pumped by two 400-gallon homogenizers, direct to the Vacreator, where it is pasteurized at 200 degrees F. and then discharged to two cabinet coolers. These coolers, which were originally designed to handle mix pasteurized in the vat at 160 degrees, are now able to cool the colder mix, coming from the Vacreator, from approximately 110 degrees F. down to approximately 32 degrees F.

Definitions of some terms that were used in the lectures

LATENT HEAT - The heat that must be applied to a substance in order to affect a change in state without a change in temperature; e.g. latent heat of fusion of ice-water is 80 calories/gm.

LATENT HEAT OF EVAPORATION - The heat required to change unit mass of a liquid to vapor at constant temperature.

SENSIBLE HEAT - Heat which can be measured by a thermometer.

SPECIFIC HEAT - The ratio of the amount of heat required to raise the temperature of a gram of a substance one degree Centigrade to that required to raise the temperature of 1 g. of water one degree Centigrade.

HEAT OF VAPORIZATION - Heat absorbed during isothermal vaporization when there is equilibrium between two phases.

DRY SATURATED STEAM - Saturated steam is steam having the same temperature as boiling water due to its pressure (heat saturated). Dry steam is steam that contains no moisture; it may be either saturated or super-heated. Dry saturated steam, therefore, is steam that is neither wet nor superheated.

SUPERHEATED STEAM - In this condition the pressure is not determined by the temperature as for saturated steam but, instead, the two may be selected independently. The temperature, however, must always be higher than the saturation temperature at the stated pressure.

ENTHALPY - is the name given a composite property of the thermodynamic system which is of great convenience, especially in the study of the thermodynamics of vapors, such as water vapor or steam. If heat is added to a system under a condition of constant pressure the enthalpy of the system will be increased by exactly the amount of heat added. Alternative terms: heat content, total heat, thermal potential.

DISTILLATION - The process of vaporizing a liquid and condensing the vapors by cooling.

DIFFERENTIAL DISTILLATION - (simple distillation). Distillation where vapor generated by a boiling liquid is withdrawn and condensed as quickly as it is formed.

STEAM DISTILLATION - Distillation process where steam is passed through a heated liquid. The steam carries away materials by forming volatile mixtures having a lower boiling point than the material itself.

POSSIBLE CAUSES OF ENTRAINMENT LOSS

1. The use of too much steam. That is, operating with too high a temperature rise in the condenser water. Generally speaking, when operating with the water pressures at from 70 to 80#/Sq.In., the temperature rise in the Junior machine should not be above 75 degrees and, in the Baby machine, it should not be above 45 to 50 degrees. This will vary some with the acidity of the cream being treated. With high acid cream containing large amounts of CO_2, even lower temperature rises than those mentioned for each machine may cause an entrainment loss. With sweet cream, it might be possible to operate with higher temperature rises.

2. Over-loading the machine, that is, pumping cream into it at greater rates of flow than the maximum rated capacity of the machine. The maximum rated capacity of the Baby machine is 2500#/Hr., of the Junior machine 5000#/ Hr., of the "M" type machine 15000#/Hr. These capacities should not be exceeded in pasteurizing cream for buttermaking. It is possible to exceed them slightly with entirely sweet cream, with milk, or with ice cream mix.

3. Neutralizing high acid cream with bicarbonate of soda or neutralizers containing a high percentage of bicarbonate of soda or other neutralizers that cause excessive foaming.

   Generally speaking, cream over .7 percent acidity should be neutralized with special alkali or lime or at least to about .3 or .4 percent with lime or a special alkali and the rest of the way with carbonate neutralizers, if desired.

4. Neglecting to turn the water on the water jacket. With no water on the water jacket, the cream is apt to boil excessively and some be pulled over to the condenser.

5. Operating with too much back pressure on the cream discharge pump. The cream discharge pump used on the Baby and Junior machines will pump from a 29" vacuum and discharge against a head about 10-1/2#/Sq.In.

   If the cream discharge pump is pumping through a surface or plate cooler and trouble is had with entrainment losses, it should be made certain that the cooling medium is not so cold as to cause the cream to freeze to the plates or tubes and build up back pressure.

6. Operating with the snifter valve weight set too far out on the snifter valve lever. When this is done, there may be a slight pull-over at the time the Forewarmer is just about empty. At this time, when

there is only a small amount of cream being pumped into the machine, the vacuum tends to increase quickly. The boiling point being thus suddenly reduced, the small amount of hot cream entering the chamber will boil so violently that some may be pulled up the vapor pipe and into the condenser.

The weight of the snifter valve should be set so that the vacuum in the low vacuum chamber will not exceed 20". Also, as the fore-warmer becomes empty, the amount of steam used should be reduced and the tension on the equilibrium valve lessened.

7. Air leaks in the cream discharge bend connection or in the pump cover gasket. It is possible to have a small air leak here not large enough to prevent obtaining a satisfactory vacuum on the high vacuum chamber in starting the machine but sufficient in size to allow enough air to be drawn into the machine and interfere with the efficient operation of the pump. This will cause the cream to accumulate in the high vacuum chamber, where it will "boil up" and be drawn out of the vapor pipe.

8. Milkstone accumulating in the tangential entry to the vacuum chamber. If the Vacreator is not cleaned properly and milkstone is allowed to build up in the tangential entries to the vacuum chambers, so that it forms in lumps, the cream may tend to spray to the chambers rather than spiral in a film around the walls. Cream sprayed into the chambers is very subject to the pull of the vacuum and may be drawn out through the vapor pipes.

VACREATION QUESTIONS

If true indicate by a +
If false indicate by a 0

1. The Vacreator was invented in Australia. 0

2. The idea to develop the Vacreator originated with H. Lamont Murray. +

3. The development of the Vacreator took place in a plant that manufactured 5 million pounds butter per year. +

4. Murray conceived the idea of heat treating cream under vacuum when he was engaged in condensed milk manufacture in New Zealand. +

5. Feed flavors from turnips, clovers, spring grass and miscellaneous weeds were common in milk and cream delivered to New Zealand dairy plants. +

6. The milk condensing process largely eliminated the off flavors arising from the cows eating strong-flavored feed and weeds. +

7. Pasteurization of milk to be used in butter manufacture was first used in the United States by Schuknecht, in Minnesota in 1897. +

8. The "Reid" pasteurizer was the first used for pasteurizing milk to be used in butter manufacture. +

9. Pasteurization kills about 99.5 percent of pathogenic bacteria. 0

10. All yeasts and molds are destroyed by pasteurization. +

11. Vacreation kills all bacteria. 0

12. Some disease-producing bacteria may survive boiling at 212 degrees F. 0

13. Pasteurization is as effective as sterilization. 0

14. Flash pasteurization of cream with a jacketed centrifugal heater means heating cream to nearly 200 degrees F. +

15. Sterilization means destroying all bacterial life. +

16. The evolutionary period in the development of the vacreation process was from 1923 to 1933. +

17. Vacreated cream butter keeps better than flash-pasteurizer cream butter in accordance with New Zealand tests. +

18. The first Vacreator was installed by the Northern Wairoa Cooperative Dairy Company at Dargaville, Auckland Province, New Zealand. +

19. The first commercial Vacreator was installed during the year 1932. +

20. Approximately 200 million pounds of the butter exported from New Zealand to Great Britain in 1938-39 was made from vacreated cream. +

21. In 1939 there were 131 Murray vacuum pasteurizers in use in Australia. +

22. There are no Vacreators in Africa. 0

23. Butter is now made in France from vacreated cream. +

24. At present 700 million pounds of the 800 million pounds butter manufactured in Australia and New Zealand are made from vacreated cream. +

25. One New Zealand creamery uses a battery of three "M" type Vacreators. +

26. Vacreation has replaced the flash and the vat-pasteurization methods in Australia and New Zealand for 5 reasons. +

27. The first Vacreator chamber has the highest vacuum. 0

28. The second Vacreator chamber has the lowest vacuum. 0

29. The higher the vacuum the higher the boiling point of water. 0

30. Pasteurization takes place just after the cream passes the equilibrium valve. 0

31. A positive phosphatase test in butter is positive proof that the cream from which it came was effectively pasteurized. 0

32. When a boiler is said to "prime" it is running low on water. 0

33. The steam pressure-reducing valve should be installed immediately above the Vacreator. 0

34. The equilibrium valve regulates the vacuum in the second chamber. 0

35. Cream is diluted with water from condensed steam to the extent of 20 percent, when the cream is at a temperature of 60 degrees F. before vacreation. 0

36. If the cream enters the Vacreator at 110 degrees F. and leaves at 110 degrees F. there is no significant change in composition of the product. +

37. Scorching of cream may be caused by superheat in the steam. +

38. A steam pressure of 100 pounds per square inch gauge should be used for vacreating. 0

39. Superheated steam is best when vacreating. 0

40. The minimum permitted pasteurization temperature when the Vacreator is used for cream to be used in butter manufacture is 185 degrees F. 0

41. The Vacreator must be equipped with a safety thermal limit recorder controller to meet the Oregon State regulations. +

42. A minimum pasteurization temperature of 190 degrees F. for ice cream mix has been established by the Oregon State Department of Agriculture. +

43. The regulations for cheese milk vacreation are similar to those for churning cream. 0

44. The Snifter valve regulates the pasteurization temperature in the Vacreator. 0

45. To regulate "treatment intensity" adjust the steam inlet valve. +

46. A vacuum of 6 inches corresponds to a water boiling temperature of 160 degrees F. 0

47. A vacuum of 20 inches corresponds to a water boiling temperature of 200 degrees F. 0

48. The liberal use of jointing compound when erecting the steam line is beneficial. 0

49. Velocity of water is calculated in accordance with the following formula:

$$\text{Velocity} = .94\sqrt{2gh} \text{ feet per second}$$

50. Gallons per minute are calculated in accordance with the following formula:

$$\text{Velocity in ft/sec} \times 60 \times 12 \times \text{area} \div 231 =$$

51. Pounds water per hour are calculated from U. S. gallons per minute as follows:

Gallons per minute x 500 =

52. The symbol "h" when calculating water flow means:

H = head in feet based on absolute pressure.

53. When flash pasteurizing cream as compared with vat pasteurizing, the percent of the total fat churned that is lost in the buttermilk is generally less.

False. It has been shown that there is more fat lost with flash pasteurized cream.

54. When efficiently manufacturing butter from vacreated cream the percent of the total fat churned lost in the buttermilk should not be more than

1.00 - 1.25%

55. The test to use when determining the amount of fat in the buttermilk is Babcock-Butyl Alcohol Method and is performed as follows:

Adjust temperature of buttermilk to 60-70 degrees F., carefully mix sample, pipette 8.8 ml. of buttermilk to test bottle, add 2 ml. Normal Butyl alcohol, mix, add 7-8 ml. sulphuric acid, mix well, Centrifuge 6, 2 and 2 minutes, adding 140 degrees F. water between periods, place in 135-140 degrees F. water bath for 5 minutes and take reading, double reading for correct per cent of fat.

56. When churning 25% fat cream and the buttermilk test is 0.60 percent, what is the percent of the total fat churned that is lost in the buttermilk?

25# fat
25 + (25 x 1/5) = 30# unsalted butter
100 - 30 = 70# buttermilk

70 x .6% = .42# fat lost

$$\frac{.42 \times 100}{25} = 1.68\%$$

57. If 35% fat cream is churned and the buttermilk fat test is 0.60, what is the percent of the total fat churned that is lost in the buttermilk?

35# fat
35 + (35 x 1/5) = 42# unsalted butter
100 - 42 = 58# buttermilk
58 x .6% = .348

$$\frac{.348 \times 100}{35} = .994\%$$

58. What factors in churning proper may cause an increase in the amount of fat lost in the buttermilk?

1. Churning low fat cream
2. Churning at high temp.
3. Overloading the churn
4. Dilution with water

59. Entrainment loss during vacreation is caused by

1. Excess steam entering machine
2. Loss of balance of vacuum in #2 & 3# chamber
3. Too great a volume of CO_2 - using Na bicarbonate neutralizers on high acid cream
4. Overloading the machine
5. Neglecting to turn water into jackets

60. By "treatment intensity" is understood that the amount of steam admitted to the vacreator over and above that necessary for pasteurization can and should be adjusted as deemed sufficient on the basis of the intensity of the feed or weed flavor in the milk or milk products.

61. When pasteurizing 5,000 pounds cream per hour at 200 degrees F., the cream leaves the Vacreator at 100 degrees F. If 15,000 pounds water per hour goes through the condenser, what is the "safe minimum" rise in the condenser water?

$$\frac{5000 \times (200-100)}{15000} = 33 + 10 = 43 \text{ degrees F.}$$

62. What is the "treatment intensity" figure in problem 61.

$$\frac{1500 \times 43}{5000} = 129$$

63. Find the minimum temperature rise of the condenser water if the treatment intensity figure in problem 61 were 200.

$$\frac{5000 \times 200}{1500} = 667 \text{ degrees F.}$$

64. If onion-flavored cream is treated as in problem 61 what should be the "treatment intensity" figure? Show calculation.

Use intensity of 225 or above

$$\frac{5000 \times 225}{1500} = 75 \text{ degrees F. temp. rise required}$$

65. A cooked-scorched flavor is caused by the presence in the milk or cream of the following products:

Milk Solids - Sulphides
Fat - "Scotching" making sort of a butterscotch flavor

66. The following are 5 reasons why cream for butter is vacreated:

1. Produces more uniform butter.
2. Effective removal of feed and weed flavors.
3. Brings about more efficient neutralization of cream.
4. Improves keeping quality.
5. Very efficient in destroying bacteria, and molds.

67. The phosphatase test is used by health authorities because:
It has been shown that the enzyme phosphatose is destroyed when the time - temperature point in pasteurization is properly reached. This enzyme can be easily tested for and because complete pasteurization covers the thermal death point of all the pathogens, this test has been accepted.

68. A negative phosphatase test indicates that:
The milk has been properly pasteurized and the enzyme phosphatase is destroyed.

69. The Vacreator is prepared as follows for starting:

1. Drain condensed water from steam line.
2. Free equilibrium valve lever.
3. Open vacuum breaking locks and loosen recording thermometer nut at bottom of pasteurizing chamber.
4. Loosen joint between low vacuum chamber and uptake pipe to high vacuum chamber.
5. Open main steam valve and the sterilizing steam valve (3rd).
6. After steam has been on for 10 min., tighten joint at bottom of 2nd chamber and also recording thermometer bulb. Leave steam on.
7. Turn on water in jackets for 5 minutes to seal pump.

70. Scale in the ejector condenser is removed as follows:
The cone assembly is removed and washed out with acid cleaner. The circulating method is used at intervals by circulating a scale removing solvent.

71. The Vacreator is cleaned as follows:

1. Water rinse to push out product.
2. Disconnect pipe to cooler and connect circulating pipe.
3. Add alkaline cleaner (#1 to 5 gal. water), for 10-20 minutes, circulate.
4. Discharge solution and flush with water for about 5 minutes or until well rinsed out.
5. Add water till machine is maintaining steady flow, shut off.
6. Drain, dismantle machine, and wash each part.

72. The recommended "Safety Thermal Limit Recorder Controller" for a Vacreator is No.
X181 RV176 for baby, Junior
X181 RV168 for Vac. 3 & Vac. 6

73. Failure to obtain sufficient vacuum may be:
1. Ejector condenser plugged with scale.
2. Water pressure through condenser low.
3. Air leaks around connections.
4. Discharge pump not sealed.

The following are true or false.

74. The Oregon and Iowa results showed an increase in the score of butter due to vacreation of good quality cream of nearly one full point in score. +

75. Yeasts may cause rancid flavor in cream. 0

76. Putrid cheesy flavor in butter is always caused by improper pasteurization. 0

77. Lipase is a bacterium. 0

78. The "M" Vacreator handles twice as much cream as the No. 6 machine. +

79. The overall width of a No. 6 Vacreator viewed from the front is 54 11/16". +

80. The height of the No. 3 Vacreator from floor to condenser water inlet is 83 5/8". +

81. There is a 140 lb. difference in the shipping weight of the No. 3 and the No. 6 Vacreator. +

82. The water pump on the No. 6 Vacreator uses a 5 HP motor. 0

83. The steam requirement per 12,000 pounds product for a No. 3 Vacreator is the same as for an "M" machine. +

84. The discharge pump on the "M" Vacreator uses a $1\frac{1}{2}$ HP motor. 0

CLOSING REMARKS

by
W. W. Monroe
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Professor Brandt and Dr. Wilster: I wish to congratulate and thank you and your staff in behalf of the Monroe Dairy Machinery Company and the Cherry-Burrell Corporation for what I know has been an outstanding short course.

Many of our personnel have stated to me that this is the finest and most informative short course they have ever had the privilege of attending. Dr. Wilster is to be highly complimented not only for the outstanding contributions he has made to this short course, but for the fine job of organizing. I marvel at how well acquainted and versed those professors not connected with the dairy department at Oregon State College are with the Vacreator and its functions.

In closing I would like to express our appreciation to those participants not present now for their very fine presentations. Also I hope that this short course is only the first of many similar courses to be held in the future.