TECHNICAL PRODUCTION OF MILK CONCENTRATES

Papers in Dairy Marketing
Presented at the Agricultural Industries Forums
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Introduction

The dairy industry is on the verge of a change that will affect every dairy farmer, every dairy cooperative, and every fluid milk distributor in the United States. Causing this change is the introduction and sale of concentrated milk in fresh, sterile, or dry form that can be used as a substitute for fresh whole milk. Concentrated milk is likely to have an even greater impact upon the fluid milk industry than foreign cars and small American cars have had upon the automobile industry during the past two or three years.

Papers presented at the Agricultural Industries Forums in 1960 and 1961 tell something about the technical processes used in the production of milk concentrates.

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Problems in Making Sterile Concentrated Milk with Ultrahigh Temperatures

In making 3:1 concentrated milk, water is removed from whole milk in the vacuum pan in the same way as it is removed for regular evaporated milk. The milk is preheated before it is condensed, and the time and temperature of preheating greatly affect the physical properties of both the fresh and the stored product. The concentrated milk containing 36 to 38 per cent of total solids may be sterilized in a tubular heater, in a plate heater, or by direct steam injection. There are several modifications of the conduction heaters, and there are combinations of steam injection and conduction heaters. The product may be preheated and heated to sterilizing temperature in one to two seconds and held for two to six seconds, depending on the type of equipment and the temperature. There are many time-temperature combinations that might be used for ultrahigh-temperature heating. Insofar as is known, the best and most practical combination has not been reported — that is, the combination that affects the desirable flavor and physical structures of the products least and maintains them longest. The concentrated product may be cooled in four to ten seconds, depending on the type of cooler and temperature and velocity of the coolant. This product is canned, aseptically, after it is sterilized.

Concentrated sterile milk produced by the ultrahigh-temperature process is not noticeably different in color from the original milk. It reconstitutes to an acceptable glass of beverage milk, but one that trained observers can distinguish from regular pasteurized milk. It does have a

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cooked or heated flavor that gradually lessens during storage but does not disappear entirely. This flavor is inevitable; it can not be avoided when the conventional conduction and steam injection heating methods are used to achieve sterility. The concentrated milk will maintain appearance and palatability acceptability to the consumer for about two months at 70° F. storage, for about three weeks at 100° F. storage, for three to four months at 60° F. storage, and for five to six months at 32° to 40° F.

The most important problem in processing and storing sterile 3:1 concentrated milk is gelation. It is accompanied by increased viscosity and solidification upon separation of the whey. Gelation occurs most rapidly at the higher storage temperatures (above 70° F.). Concentrated milk can be reconstituted after storage for five to seven months at 32° to 40° F., but eventually a solid gel forms with separation of the whey and lactose crystallization may occur. How much gelation can be retarded without injury to the flavor and to the desired physical properties of concentrated milk can not be determined now, but some information has been obtained.

Preheating whole milk at 180° F. and holding it for 10 to 30 minutes about doubles the viscosity of 3:1 concentrate compared with preheating whole milk at 180° F. for four seconds. Concentrated milk with a high initial viscosity gels faster than that with a low initial viscosity.

Sterilization temperatures affect viscosity and rate of gelation. Concentrated milk sterilized at 285° F. and held for two seconds will have a higher initial viscosity, increase in viscosity faster, and gel faster than the same milk sterilized at 300° F. for two seconds. After eight weeks of storage, the milk sterilized at 285° F. was about three times more viscous than the same milk sterilized at 300° F., and gel had begun to form.

Gelation can be retarded by heating concentrated milk considerably above the temperatures required for sterilization without having much effect on the color, but the body of the product becomes coarse and grainy.

Sufficient initial viscosity is needed in concentrated milk to prevent settling of solids during storage, and this is related to the preheating temperature. Heating whole milk in a tubulex heater to 180° F. and holding it for four seconds develops sufficient viscosity, but preheating it to 140° F. and holding it for 30 minutes is not sufficient to prevent settling of solids in sterile concentrated milk during storage at 70° and 100° F.

To prevent as much damage as possible to the milk and to retard burning milk solids onto tubes and plates, it is necessary to have a small temperature difference between the milk product and the steam. This difference is about 5° to 6° F. for our tubular heater at the final heating cycle, but is much greater at the beginning. High temperature differences between heating medium and the fluid milk product cause the formation of particles of milk solids large enough to be seen with a microscope at a magnification of about 450 times. These large particles increase viscosity and, presumably, accelerate gelation.

Homogenization has profound effects on the structure of sterile milk. It causes the formation of fat-protein combinations. Unhomogenized sterile milk does not have measurable combinations of fats and proteins. Homogenizing sterile milk at 150° to 160° F. results in deep formations of fat-protein structures, but they are very shallow in milk homogenized at sterilizing temperatures. These structures in mass were observed by spinning milk in a high-speed centrifuge, at the same time taking pictures of the settling solids, and then measuring the depth of these solids from a negative of the picture. Undoubtedly this fat-protein combination functions to maintain a stable system whereby the fat will remain distributed and the proteins will not settle during storage. The effect of this fat-protein combination on the gelation of concentrated milk has not been determined.

For 3:1 concentrated milk to make an impact in the dairy industry under variable temperatures of storage and transport such as are imposed on regular canned evaporated milk, it will be necessary to solve the problem of gelation. Present knowledge indicates that the product must be refrigerated and that the required temperature will depend upon the duration of storage.

Finally, we might need to revise our ideas about the storage qualities that we demand of sterile fluid milk products. We may be demanding the maintenance of storage qualities that are difficult, if not impossible, to achieve. At storage temperatures of 80° to 100° F., fluid milk products quickly develop off-flavors and the objectionable brown color. In fact, this color develops in dried milk powders at high storage temperatures. Insofar as is known, the natural flavors, nutritional properties, and physical characteristics of the more simple foods can not be maintained at high storage temperatures for relatively long periods. This has been emphasized at various times during the past decade. The logical, simple, and more certain way is to use refrigeration to preserve the natural properties of sterile fluid milk products. Undoubtedly physical and chemical stability are associated with both flavor stability and consumer acceptability.

Processing Sterilized Concentrated Milk

ARTHUR M. SWANSON[1]

The dairy industry has recognized the need for a concentrated milk product that will store for a considerable period without appreciable changes in flavor and body characteristics. On reconstitution with water the product should be comparable to fluid milk. To achieve these keeping qualities, the product must be sterilized — hence the name "sterile" or "sterilized" concentrated milk.

A review of the scientific and patent literature shows that this has been the objective of many individuals over the years. Researchers had found that the heated flavor and color changes could be minimized by sterilizing the product at a higher temperature for a shorter period. The difficulty with this type of treatment was that the resulting product did not have storage stability. Gelation would occur. Fat separation and flavor deterioration were also encountered.

These reported observations were far from encouraging, but the desirability of having a sterilized concentrated milk prompted others as well as ourselves to continue work on this product. The work at the University of Wisconsin has been a team effort in which many departments have shared in various phases.

I will attempt to describe our approach to the problem and our work in developing a process for the manufacture of a sterilized concentrated milk.

The problem that intrigued some of us most was gelation. In order to study gelation, we had to install equipment for manufacturing the product we wanted to study. This was not a test-tube procedure or even a laboratory bench setup. It required the installation of a pilot plant capable of heating milk and concentrate up to 295° F., concentrating the milk, homogenizing it, and canning the sterilized product under aseptic conditions. We decided on a setup that would process milk at

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the rate of 1,200 pounds per hour. Our first setup was definitely a batch operation. It has been revised from time to time as refinements in the process have been developed.

Our work has been principally on a 3:1 concentrated milk. This product is of such concentration that one part of concentrate mixed with two parts of water will give a reconstituted product similar in total solids content to the milk from which it was made. The question is often raised, "Why did you decide on the 3:1 concentrate when it was known that such a product was difficult to produce?" We decided that if the objective was to remove water to minimize shipping and storage costs, then we should try to remove as much water as possible. Again, we are asked, "If this was the reason for 3:1, why didn't you go to a higher concentration, such as 4:1?" We knew that there was a critical range in regard to lactose crystallization, and if the solids concentration was around 36.0 per cent (3:1) or less, lactose crystallization would not be a problem.

Evaporated milk has long been a stable item of commerce. It is produced by concentrating milk to 25.9 per cent total solids. Sterility is achieved by heating the concentrated milk in cans from 242° to 245° F. for fifteen minutes. To achieve stability during sterilizing, the milk, before being concentrated, is subjected to a forewarming treatment; and a stabilizing salt, such as disodium phosphate, is often added to the milk or concentrate. The interesting thing is that evaporated milk will store for at least a year at room temperatures and will not gel. It is true that on rare occasions gelation may be found, but it is the exception rather than the rule. The principal storage defects of evaporated milk are fat separation due to age-thinning of the product rather than age-thickening, color changes, and flavor changes.

We looked to evaporated milk to furnish some of the answers to the problem of gelation. We reasoned that during the processing of evaporated milk the product undergoes some form of gelation, which is evident from the increase in viscosity during the sterilizing process. The additional heat and agitation brings the product through the gelation phase. After sterilization, the product is stable so far as gelation is concerned.

Considering the problem of gelation in high-temperature, short-time sterilized concentrated milk, we reasoned that the heat treatment and agitation were not of sufficient duration to bring about changes in the physical-chemical properties of the product that would produce stability. To achieve this objective, we started to develop processing procedures to increase the viscosity (body) and then reduce viscosity by vigorous agitation.

Before working on sterilized concentrated milk, we had done some work on improving fresh concentrated milk. Gelation was found to be the principal defect. We decided to obtain maximum keeping properties without applying too much heat to the product in concentrated form. It was possible to do this by subjecting the fluid milk to sterilizing temperatures of 295° F. for two to three seconds and then cooling it immediately by flashing into the evaporator. This treatment proved successful in reducing the bacterial count, because it is easier to destroy microorganisms in the fluid milk than in the concentrate. Also, flashing the milk into the evaporator reduced the heated flavor in the finished product.

This step, which we considered very desirable, was made a part of the sterilized milk concentrate processing procedure. After being concentrated, the product was standardized. Then it was again subjected to another sterilizing treatment. In the system that was first used, the product was partially cooled as it came from the high-temperature, short-time sterilizing treatment and then collected in an aseptic collection vessel. As the product was held in this vessel, it increased in body. This suggested the possibility of reducing the viscosity by homogenization. We found that the rate of viscosity buildup would be changed by changing the forewarming temperature of the milk before the high-temperature treatment. Reducing the forewarming temperature causes the product to become more viscous. We found it possible to control gelation by homogenization of the concentrate. The degree of success depends upon homogenizing at the proper viscosity. This is achieved by controlling the forewarming temperature and the temperature of the concentrate from the cooling unit following sterilization.

We found that seasons of the year affect the rate of body buildup, which follows the same pattern as for evaporated milk. In 3:1 high-temperature, short-time sterilized concentrate gelation can not be controlled as effectively by adding stabilizing salts as it can be in evaporated milk.

In summary, to make sterilized concentrated milk, we first subjected the milk to a forewarming heat treatment. Temperature on time of holding is dependent upon the individual milk supply and the time of the year. The milk is then subjected to a sterilizing treatment before being concentrated. After being concentrated and standardized, the product is again sterilized and subjected to a viscosity buildup treatment. This treatment may occur either before or after sterilization. The product is then homogenized and aseptically canned.

It is difficult to state definite processing times and temperatures, because various pieces of processing equipment will have different heating characteristics. For each installation it will be necessary to work out a different processing procedure.

Although we have pilot plant facilities and are capable of making several hundred cans at a time, we are not sure that these procedures can all be directly adapted to large-scale operations. We are satisfied that at the present time there are no insurmountable problems. We are counseling and have counseled with organizations that are interested in developing sterilized concentrated milk.[2]

I wish to acknowledge the contribution of the United States Steel Corporation in supplying funds for this study.

[2] Sterilized concentrated milk has been sold in our salesroom for the past two years. The comments as a whole have been very favorable to the product. The principal complaint is that, because of limited facilities and demand for research studies, we have not been able to give customers a regular supply and the quantities they desire.

Eight Years' Experience with Fresh Concentrate

C. A. IVERSON[1]

Fresh concentrated milk originated a hundred years ago, but it became an industrial rather than a consumer product. Its revival as a consumer product was attempted about 1934 and again about 1950 at several places.

Work on fresh concentrate at Iowa State began in March 1951 with relatively high-temperature vacuum evaporation and high pasteurization temperatures. The results were favorable, and the conclusions drawn from this study are summarized as follows:

1. High-quality milk must be used to prepare this product.

2. A preheating or pasteurizing treatment is necessary before condensing.

3. Experience with the single-stage homogenizer indicates that the product must be homogenized both before and after condensing to prevent a cream layer from forming after storage for seven to ten days. However, one homogenization might suffice when other types of homogenizers are used.

4. An acceptable product can be produced by condensing at the usual vacuum pan temperatures of 125° to 135° F. However, condensing at these temperatures will produce varying degrees of a flavor which we have called "harsh cooked" and "stale." This flavor can be changed to a pleasing, mellow-cooked, rich flavor by pasteurizing at 180° F. for 16 seconds after concentration.

5. Most people agree that the reconstituted product has a fresh milk flavor and is relatively free from volatile feed and grass flavors.

6. Experience has shown that any major deviation in the processing procedure will be reflected in the flavor score of the finished product.

7. The relatively good keeping quality of the product is due to pasteurization at high temperatures, double pasteurization, and low holding temperatures. The concentration of milk solids is not sufficient to inhibit

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bacterial growth, and the vacuum treatment does not have any demonstrable effect on the bacterial population during storage.

With the development of a superior product came the need to decide what to do with it, since similar products on a low-temperature basis had not been successful. The decision was made to attempt to sell the product in the rural areas surrounding Ames, since at the time no pasteurized milk was being delivered.

Two side results accrued from this research and development work:

1. Since higher temperatures were used successfully in processing concentrated milk, recommendations were made that all homogenized milk be pasteurized at higher temperatures than had previously been used (this was an important contribution to the industry).

2. With the development of rural sales of concentrated milk, many milk processors began successfully experimenting with retail rural deliveries of regular fresh milk.

For rural deliveries a special truck body made from magnesium metal was developed, and a mechanical refrigeration unit was installed. Deliveries were made to farm homes once a week. Besides concentrated milk, such other dairy products as ice cream, prepackaged cheese, and cottage cheese were included. The concentrated milk was welcomed by the rural population:

1. On farms where only one or two cows were kept to produce milk for home consumption because: (a) cost of home-produced milk was very high — one farmer estimated it at nearly 50 cents per quart; and (b) home pasteurization was laborious and resulted in milk with a marked heated flavor.

2. On farms selling milk and cream because of: (a) health hazards in consuming "raw" milk; and (b) difficulties involved in pasteurizing milk in the home.

Farm families reported a tremendous increase in the per capita consumption of milk and ice cream with home delivery of these products. Although exact records were not available on previous milk consumption, rural housewives estimated that per capita consumption of milk increased by approximately 50 per cent almost immediately.

Arriving at a suitable margin for the vendor of fresh concentrate became an immediate problem. No cost figures were available on rural distribution of milk. Distances traveled were much greater in most instances, although, in certain cases the distance was less (i.e., in one instance 60 quarts of fresh milk equivalent were delivered within a relatively small area). A figure of 12 cents per quart of concentrate was established, inasmuch as the vendor of our fresh milk in Ames was receiving four cents a quart at the time, allowing eight cents a quart for the raw product and plant costs. On the basis of further study, the 12-cent figure appears to have been reasonably fair to the vendor and the processor on a rural basis.

Keeping quality of the product has never become a problem. Processing has been carefully done, and the product has been consumed well within its useful life. Elsewhere some undesirable results have been experienced (western Iowa distribution center, experience of large milk cooperative in Illinois).

Keeping quality has been unusually good in some instances; some milk has been sent by ship to Venezuela, and some has been shipped by air to Winnipeg. Processing results and keeping quality have been checked in every lot produced during the year by a staff member using a sample in his own home, notwithstanding the fact that the product was not sold at retail in Ames.

The type and quality of water used in reconstituting the milk has not been a problem to our knowledge except in two instances:

1. Of all the farms serviced with concentrate in the Ames area, only one farm well produced unsatisfactory water.

2. The Modern Dairies of Winnipeg, Manitoba, encountered treated water at certain seasons of the year that proved to be unsatisfactory for reconstituting purposes.

The higher heat treatment for producing fresh concentrated milk has been adapted elsewhere:

1. Prairie Farms Creamery, operating in 13 counties in central Illinois, has successfully produced and distributed fresh concentrate from Bloomington and Henry.

2. A large dairy in Winnipeg, Manitoba, is distributing fresh concentrate at Fort Churchill on Hudson Bay at a saving of five and one-half cents per quart (Imperial) of fresh milk equivalent, due mainly to a transportation cost of seven and one-half cents per quart from Winnipeg for either concentrate or fresh fluid.

3. A large grocery chain operating extensively on the Pacific Coast used the heat treatment on its fresh concentrate, which constitutes a large sales item.

4. A large milk plant in eastern Iowa attempted to process and distribute fresh concentrate both in that area and in western Iowa through a distribution center. The results were not satisfactory because of technical difficulties and a poor sales program.

5. A large cooperative milk marketing organization in Illinois says it abandoned its attempts to produce and sell the product, largely because of over-optimism regarding keeping quality and lack of uniformity in keeping quality.

6. Other universities have been experimenting further in developing sterile fresh concentrate.

Fresh concentrate may have some unusual qualities that are not present in the original milk. It may also be a means of getting larger amounts of milk into children's diets without giving them too much liquid.

Frozen fresh concentrated milk looked very promising, but year-round trials indicated that unstable milk in late May and in June produced a product that thickened at household deep-freeze temperatures. Altering the degree of concentration should help to correct this fault, or the method may still be useful in a country like Japan with a winter surplus. Freezing fresh concentrate offers a satisfactory method of storing milk solids for use in the plant, however.

The byproducts of eight years' experience with fresh concentrate may easily be more important than the production and retail sale of the product itself. Experience with higher temperatures used for pasteurizing the milk both going into and out of the vacuum pan have altered our concepts of proper heating for homogenized fresh milk. The experience of having this product available for use in other products in the plant has encouraged us to believe that these uses may be more important than the retail sales. Some examples are use in half and half, in low-fat milks — skim milk and 2 per cent — and in ice cream mixes. High-quality milk solids can be stored as fresh concentrate for short periods, and frozen concentrate for longer periods.

Production and Sale of Sterile Milk from Our Laurel, Maryland, Plant

WILLIAM B. HOOPER[1]

I have been asked to participate in this discussion today with respect to the "Production and Sale of Sterile Milk" from our manufacturing division plant in Laurel, Maryland. As background, it may be of interest to take a brief look at the Maryland and Virginia Milk Producers Association, which is a dairy farmers' cooperative supplying approximately 80 per cent of the fluid milk for the metropolitan Washington, D.C., area, and handling 100 per cent of the surplus. Our association is composed of some 1,800 dairy farmers, most of whom are located in the states of Maryland and Virginia, with a small number in West Virginia and Pennsylvania. We have an approximate average daily volume of 235,000 gallons of milk, with fluid sales of about 185,000 gallons per day. All association members produce "Grade A" milk for the metropolitan Washington area. We are rather proud of the fact that our average bacteria count is less than 20,000.

The association was first organized as a cooperative in 1920 and for a brief time operated a small surplus manufacturing plant in Washington. This was unsuccessful and was soon abandoned. From 1924 until 1954 the association operated wholly as a bargaining association and had no processing facilities.

In 1954 the association purchased Embassy Dairy, a fluid milk plant operating in Washington, D.C., and since that date has operated this dairy, which distributes under its own name 35,000 gallons of fluid milk per day in the Washington market.

In December, 1955, the association purchased a small manufacturing plant located at Laurel, Maryland. This plant had been operated mainly as an ice cream mix processor; its capacity was limited to about 35,000 gallons of milk daily. Up to the time of purchase of the Laurel plant, the association's surplus was handled wholly by a manufacturing plant

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owned and operated by the National Dairy Products Corporation, Frederick, Maryland. The Laurel plant was acquired because a need was felt for additional manufacturing facilities in the market and also to give the association its own outlet for surplus milk.

Shortly thereafter the plant and its operations were expanded to give greater capacity and flexibility. The roller powder drying equipment was disposed of, and spray powder machines with a total capacity of 5,000 pounds of powder per hour were installed. More condensing equipment was added to balance the powder operation, as well as a continuous butter operation capable of processing 2,200 pounds of butter per hour. We are also currently enlarging the operation to provide additional storage of 60,000 gallons of fluid milk; we are putting in a separation line which will handle 8,700 gallons of milk per hour, and adding a cottage cheese operation designed to produce about 70,000 pounds of cottage cheese per day.

In 1958, while expanding and setting up these new processes in the Laurel plant, the association also decided to install a sterile milk operation with aseptic filler equipment. Since we looked at the sterile milk process as a means of converting some of the surplus milk on our market into a higher dollar return product, our interest was at first confined solely to the possibilities of sterile ice cream mix and milk shake mixes. The various processes that we checked did not fit into our contemplated operation; the main deterrents were the small-volume production and the manpower required. We were interested in a process which would utilize to the utmost the efficiencies of our particular plant and its big volume and high-speed production.

Finally we investigated a sterile operation in Switzerland, a process known by the trade name of "Uperisation" operated by the Bernese Alps Milk Company. After thorough study we decided that this process was the best for our purpose; we entered into a contract with the Swiss people to purchase the processing equipment together with the necessary licenses and franchises to operate in the United States and its territories.

Most of you here are familiar with the process. It is steam injection whereby the milk is subjected to superheated steam at about 304° F. for 2.4 seconds, immediately cooled, and aseptically canned by the Dole Aseptic Filler. We have a maximum capacity of 1,250 gallons of sterile milk per hour, using a #10 can. The production rate is reduced proportionately when smaller size cans are used. At the present time we are using only the one size, the #10. In this connection it might be of interest to know that we have contracted for the installation of a sterile paper Tetra-Pak half-pint line, but it will not be installed or be operating for approximately three to five months.

As stated, our primary purpose in investigating and adopting a sterile milk process was to increase the dollar return from manufactured products, primarily ice cream and milk shake mixes. It appeared to us that there was a very considerable market for ice cream mix and milk shake mix which was not being fully tapped by the present method of distribution in 3, 5, and 10 gallon cans. We felt that there was a tremendous untouched market for a product with long shelf life which could be put up economically in smaller containers. We have made some experimental runs with both sterile ice cream mix and milk shake mix: we are very well pleased with the quality as well as the products' shelf life and plan to go into volume production of these products in the near future.

As fluid milk market people we recognize the dominant position of fluid milk sales in any market. There would be no point in doing anything which could harm our fresh milk Class I fluid sales except as a competitive measure. Our living is based on sales of Class I milk. And it is doubtful whether milk merchandised in sterile form could command the full Class I price. Therefore, protection of our Class I markets is an economic consideration that we can not overlook. We are not interested in replacing fresh fluid milk sales with sterile milk if its effect is to reduce returns to dairy farmers.

As our experimental work continued, it was not very long before the potential of sterile milk became obvious. It could not be ignored. Our experimental runs of sterile milk proved the product to be good — not equal to fresh milk in our opinion, but better than most reconstituted products. The armed services offered a ready-made market, particularly for overseas use or aboard ship. To date that is the only market we have attempted to supply. In order to exploit to the utmost our particular operation, we have limited our production to the armed services, standardizing on #10 cans, and only bid on contracts which would give us at least three to five days' run at the rate of about 6,000 gallons of product per day.

We recognized the fact that we were primarily set up to handle volume production, and not retail distribution. It is not our intention, unless forced to, to enter into retail distribution of sterile milk or milk products. We feel that in our particular operation we can most efficiently operate by staying strictly in the production and processing field. Further, we have no intention of using sterile milk to compete in the fresh milk market unless we are forced to in defense of our own market.

I would like to discuss with you some other aspects of the sterile milk process which I believe are of prime importance.

We, and I believe many others in the eastern markets, are acutely aware of the implications and importance of sterile milk. It is being given a lot of attention by the milk industry and the farmer organizations in the East. I can not speak officially for the other eastern markets and do not set myself up as their spokesman or representative, but I feel certain that most of the responsible fluid milk cooperatives will concur in most of what I have to say in regard to sterile milk and our fluid markets.

When I use the phrase "sterile milk," it is in the broad sense to cover both whole milk and concentrate. Sterile milk can either be a boon to the fluid milk industry and the dairy farmers, or it can be a nightmare. If this process is utilized by special groups to dump either total or surplus production in fluid markets, then I think we have serious problems. A surplus created in one market is going to find its way back to other markets. The ability to convert surplus milk into sterile milk, for instance, is not the sole prerogative of any group, and used as a retaliatory measure it could mean complete and utter demoralization of the fluid milk markets, not only in the East but in the Midwest.

Used properly, this process, in my opinion, can certainly be a benefit to the fluid milk markets all over the country — to producer, distributor, and consumer. It can supplement the use of fresh milk and can increase over-all sales. Let us look at this sterile process not as a basis for usurping other established sales, but as a way of increasing total fluid milk consumption and thus benefiting all segments of our economy — producer, distributor, and consumer.

In my opinion the first thing that we all should do is work diligently and with a free exchange of information and experience to improve the flavor and the quality of sterile milk. I believe that we should set standards with respect to quality. Nothing can do more harm to the eventual sales potential than to have a few irresponsible, get-rich-quick people put out an inferior product that will set the whole process back many years as far as the general public is concerned. Only raw milk that meets the standards for fluid "Grade A" should be used. There is also much work to be done on the containers.

Then, certainly, a great deal of work should be done with respect to educating the public in the use of this milk. Here our colleges and marketing services can do much to help the milk industry. There must be an intelligent and extensive campaign. Naturally I am thinking primarily of the producers and their organizations, who can contribute by conducting surveys, for example, to determine where markets exist for this milk, where it is needed, where it can be used to best advantage — not to take the place of, but as a supplement to, fresh whole milk. Advertising and publicity of the right kind can do a tremendous job, but the wrong kind of advertising, price — the price-cutting type — can do the whole industry incalculable harm.

From my own experience I can visualize many supplemental markets for sterile milk. There are the armed forces, which have a definite need for this product. Then there are many places in this country where, because of location, transportation difficulties, lack of refrigeration, etc., fresh milk is not readily available. Certainly before trying to move in on established Class I markets we should take care of these areas. We have the weekend buyers who, because of lack of refrigeration space, can not carry enough milk to take care of their holiday and weekend needs.

All this time we have been thinking solely, or at least I have, in terms of sterile whole milk packaged in aseptic containers. But it seems to me this does not represent the big potential for sterile milk. There is no reason why sterile whole milk can not be put into *conventional* containers with an improved cap and sealing device. Thus even without refrigeration it would stay fresh and good tasting for a week or more. The savings in distribution costs alone could amount to many millions of dollars a year, most of which could be passed on to the consumer.

Now let's take a look at another sterile milk product which has received a great deal of publicity and about which many predictions are being made as to its potential and how it will revolutionize the milk-buying habits of the public. (God forbid!) I am speaking of a concentrated sterile milk. Let's assume — and I believe this assumption will soon become a reality — that production will be improved to the point that large volumes can be processed and packaged economically and the result will be a product of the highest flavor and quality. Further, imagine that an attempt is made to displace locally produced milk sold through regular channels in various markets with this concentrated product. I am assuming that it would be marketed on a price basis — that is, offered at a cheaper price than fresh standard whole milk. At least, that is the theme song as I have heard it.

Under these circumstances the most efficient volume distribution would naturally be through stores and supermarkets. I wonder with what degree of enthusiasm your supermarkets will welcome this product? Are these markets looking for milk which the housewife would have to purchase only once a week or every ten days, or are they more partial to a product with less keeping characteristics that will cause the housewife to come back two or three times a week. I am not a chain store operator, nor do I know much about their operations; but it would seem to me that if I were operating one, I would certainly not be too much in favor of supplanting my fresh milk, which I have made a point of advertising and which the housewife has to come back to my store several times a week to purchase. I would be willing to wager that very seldom does a housewife go into a store to purchase milk without picking up other commodities at the same time.

While we are speaking of the housewife, let us consider the lady herself. To what extent is she vitally interested in saving two or three pennies a day *versus* extra work? There has been a lot of ballyhoo, a lot of talk, about the cost of milk, and about how milk sales could be increased if the price of milk were reduced. But I have found no evidence that there has been any corresponding increase in the sale of milk through a reduction in price. In our own market when the gallon jug was first introduced in 1955 at a reduction of 20 cents per gallon under the standard price, there was a limited switch from home delivery to the volume package; however, it was merely a *switch* and total sales did not change. Again using our own market as an example, one of our major distributors is currently selling milk for home delivery at a cent a quart under the other distributors; yet an actual survey has shown that practically none of that particular dairy's customers realize that they are paying less than the price charged by other distributors.

From my experience I would say that the housewife is interested, of course, in saving money. But she is less interested in increasing her work load. So does it seem reasonable to assume that this same housewife who buys automatic cleaners, sprays in containers for her windows . . . everything and anything to save labor and to make her life easier . . . will look kindly upon a product that will cause her more work? Will she happily buy a product requiring her to measure out quantities of the concentrate, add water, put it in other containers, and, in most cities, use some device to take out the objectionable flavors from the water such as a filter attached to the faucet or some other method? All this is work. And is she going to go through all this to save, what — two cents a quart, or even three cents? What will it mean to her at the end of the month — a dollar, a dollar and a half, or two dollars at the most in a country where income is increasing every year. In most large markets she can buy fresh milk in gallon or half-gallon containers at approximately 20 or 21 cents a quart.

Now it is proposed, according to what I have read, that sterile concentrate would be made available to the housewife at a considerable saving. How much? Let's assume that you can sell her the concentrate at the equivalent of 17 cents a quart. The distributor or store operator, as the case may be, will make his profit. For our purpose, we will assume that the product will be distributed in a large eastern city. So we have transportation from, say, a point in Minnesota, adding another cent or so to the cost. The cost of the container, if the milk is aseptically canned, will not be insignificant. Handling and processing will not be less than standard local processing. Allow a profit for the processor, and what do we have left for the farmer who is supplying the milk? How much over the price he is now getting? To what extent is the farmer going to benefit? Just who is going to benefit?

In this theoretical problem the most overlooked fact is that the local markets will meet the competition, as I mentioned a few moments ago. Take our market for instance. Is anyone here so naïve as to think that we would not meet this competition, but would just sit back and let our Class I milk become Class III without acting to protect ourselves? We have plants, know-how, and funds. All would be used.

Also, let us not overlook the fact that federal orders would be adjusted to meet the new competition. Certainly if the federal order program is going to be maintained, it can not price fresh local milk at Class I prices and ignore sterile milk. If this sterile milk is priced as Class I, it would price itself competitively out of the market. This means, of course, that the whole problem of classification and classified pricing will need reviewing. If sterile milk is required to be made from Grade A milk, it will be necessary to price this milk to producers above the level paid for manufacturing grade milk. This is not to say that it would be priced at the full Class I price. It probably would not.

Trial and error no doubt would be relied upon to establish proper classification and class prices in light of competitive conditions which may come to the surface as a result of growth patterns for sterilized milk. In this regard the classification and pricing of *whole* sterile milk probably would not be the same as for *concentrated* sterile milk because of the variance in transportation costs between the two products. Prices paid producers for sterile milk, whether in whole or in concentrate form, would be limited to levels established for midwestern markets, plus the cost of freight.

Eastern and midwestern producers then would be in the same relative position with respect to each other as they are in at the present time. The lower freight cost of concentrated milk, and the storability of whole or concentrated milk, would probably mean a somewhat lower spread between midwestern prices and eastern prices than presently prevails for fresh whole milk in Class I uses.

We are inclined to believe that many people look at the price problem through rose-colored glasses. They vision increased sales in eastern markets by selling milk for less money than the established prices in such markets. The same people also object to eastern prices because they are too high. They fail to realize that if the eastern prices were lower, the markets would not look so attractive from the Midwest. They also fail to realize that if the apparent attractiveness really gave an advantage to midwestern milk, and if eastern milk were replaced, we would immediately move to reduce our own prices as the only means of preserving Class I sales.

Milk, like any other commodity, will be produced where it can be produced and delivered most economically. Freight costs from the Midwest and the population concentration of the East make it possible and necessary for Class I prices to be higher on the eastern seaboard than in Wisconsin, Minnesota, or Illinois. Any downward adjustment in prices would apply equal pressures to eastern producers and to midwestern producers, and, of course, time alone would tell who would survive.

Sterile milk, then, will probably change to some degree our competitive relationships. But sterile milk will in no way alter the fundamental economic considerations of milk pricing. For this reason we are of the opinion that we should all concentrate on building more sales and on improving prices for all producers.

Let's quit scheming for ways of displacing markets, because all farmers can get hurt in the process.

These are just a few of the things which I think should be considered before embarking on an ambitious program with the objective that sterile milk is going to make a Utopia for any group of producers by taking over other producers' markets. Believe me, gentlemen, producers for the eastern markets — and that is where this would be aimed — are not going to sit back and see their markets taken over or even substantially lost. They are ready to fight to retain their own outlets for milk. What I am saying is not to be considered as a threat; it is merely a plain statement of fact and morals. We can not benefit ourselves at the expense of our fellowman. The producers supplying each market are going to try to keep those markets. Let there be no misunderstanding of that basic fact.

Sterile milk and the sterile process *can be* beneficial. It can greatly extend the shelf life of milk products. It can make milk products available where they have not been freely available before. It can be a major factor in bringing *more* milk *more* economically to *more* people by cutting down on distribution costs and allowing the housewife to set up inventories. It can revolutionize our whole distribution system through its ability to better the keeping qualities of milk. It can benefit distributors by cutting down on distribution costs and on losses through returns, spoilage, etc.

If wisely handled on the basis that it is an industry improvement which makes more milk available for more uses, makes its use more flexible so that we can increase total consumption and move more milk out of manufacturing categories to the fluid and semi-fluid categories — then sterile milk and the sterile process will be beneficial, increase consumption, and ultimately give a greater return to all producers. But, used the wrong way, it will demoralize all markets and cause untold chaos and damage to the dairy industry and the dairy farmer.

Production of Sterile Canned Products in Major Brands Plant at Corning, Iowa

A. P. STEWART[1]

Major Brands' plant operation is located at Corning, Iowa. This location was selected after careful study of many possibilities throughout the Middle West. Primarily the reasons we went to Corning were the ability to obtain a high quality milk supply; availability of this milk throughout the year for steady plant operation; and a potential for increasing the milk supply which paralleled our own plans for expansion.

Corning is a town of 2,000 people located in the southwest part of Iowa 85 miles southeast of Omaha, 90 miles southwest of Des Moines, and 160 miles north of Kansas City. This section, known as the Nodaway Valley area, is similar to the better dairying regions of Wisconsin.

We have an arrangement with the Farmers Cooperative Creamery at Corning whereby the creamery collects the milk from its patrons and sells it to us. Our processing equipment, offices, warehouse, and laboratory facilities are in a common building with the creamery. This building is new, being completed approximately one year ago.

To date we have been making test packs on canned sterilized dairy products for storage studies prior to any major marketing. However, our facilities have proved ideal for the manufacture of not only canned sterilized dairy products, but also other items where retention of fresh flavor and color provide us with a quality advantage over that of competitive products. Consequently we have been engaged in producing and marketing canned fruit juice drinks plus chocolate milk and table cream for the past three to four months. Our intention is to introduce other products, including concentrated milk, whipping cream, half and half, whole milk, and certain specialty dairy items.

Glen Gillet, manager of the Farmers Cooperative Creamery at Corning, was kind enough to take a series of color pictures of our operation. Since these pictures can explain far more clearly than I the manner in which we produce our products, I will show them on the screen.

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[1] Formerly Vice-President, Major Brands, Inc., Corning, Iowa. Currently Vice-President, Nodaway Valley Foods, Inc., Corning, Iowa.

Corning is the county seat of Adams County, Iowa. The county has a population of about 10,000. The average size of farm is 260 acres. The dairy population is about 9,000 cows, primarily Holsteins, with an average of 6,500 pounds of milk per cow. This milk is almost entirely available to us, as also is that in immediately surrounding counties. The first pictures show the farm of a typical patron serving the creamery. All milk in the creamery is brought by bulk pick-up. This particular farm has 60 cows. The milking parlor arrangement and handling techniques are shown clearly in the pictures. This farmer has a direct-expansion 300-gallon farm tank, which is the most common size in the area. The pictures show the sequence of preparing to milk, the milking operation itself, and the sanitation practices.

The next scenes show the bulk tank hauler sampling the tank for later fat and bacteria tests, gauging the tank, and then pumping into the tanker. On arrival of the tanker at the plant, one wing of which is shown here, the milk is pumped into refrigerated storage tanks. The receiving room is equipped to handle three tankers at a time. Each storage tank is gauged to show its contents, with dual gauges in other parts of the plant which are using the milk from the tanks.

After being received, the milk is pumped through the raw milk processing room, where it can be clarified and sent to the canning operation. Also, it can be separated into cream and skim milk. The HTST unit will forewarm the milk prior to clarifying or separation, as well as pasteurize and cool it after separation when so desired.

The offices are pleasant and well arranged, completely air-conditioned, and equipped with telephone switchboard.

Our laboratory is designed and equipped for both quality control and research. Here we have equipment for bacteriological testing, spectrophotometer, flame photolometer, ultracentrifuge, Kjeldahl apparatus, and other special apparatus we believe absolutely necessary for manufacturing HTST sterilized, aseptically canned dairy products.

The electrical panel room houses all switches for the approximately 800 connected horsepower in the canning area. This room also has a 15 h.p. air compressor to furnish compressed air for the numerous items of air-operated equipment.

The plant has two boilers capable of generating about 600 h.p. of steam. Cooling is done primarily with ice water from two sweet water tanks.

In the sterile processing area, all tanks are accurately gauged. Tanks are equipped for both heating and cooling and have heavy agitators for preparing all kinds of special formulas. The tanks in this area are used primarily as surge tanks feeding the sterilizer and canners, although they are also used for mixing and standardizing.

Our evaporator is almost 100 per cent automatic and is capable of evaporating milk at temperatures no higher than 138° F. any place in the evaporator. All operating valves in the plant are automatic, with panel push-button control. Hand valves are used only to start an operation and to leave it in a fixed position. The evaporator has an interstage vapor heating and recompression unit. Temperatures are automatically controlled throughout.

The product to be sterilized and canned is high-temperature, short-time sterilized with equipment designed to utilize heat regeneration to a maximum extent. We are equipped for deaeration, homogenization, and a wide flexibility in temperature and holding-time sterilization conditions. We believe such flexibility is necessary because of the difference in required processing conditions for various types of products. Special controls, some of which are our own design, are employed to provide completely automatic operation. Again, all valves used during operation itself are automatic.

The warehouse is air-conditioned at 60° F. Palletized handling of empty cans and finished product is employed. Cans are received in reshipper cartons and fed to the canners via an unscrambling table and magnetic belt lift. We have two Dole aseptic canners handling a range of 8 oz. to 96 oz. cans. These canners are of the small, single-section size but will be replaced with larger canners. The evaporation and sterilization equipment is already of sufficient size to produce the volume required by larger canners.

The empty cans are sterilized with super-heated steam and then filled with the HTST sterilized, cooled product. After being sealed with sterile lids, the filled, seamed cans are washed with a chlorinated solution, rinsed, and dried.

Our casing operation is not yet completed, but provisions are being made to install automatic casers and case gluers in the near future. Please note that the point where empty cans are dumped onto the unscrambling table is adjacent to the casing station. When cans are being labeled, the labeler is inserted into the line just before casing.

Shipments from the plant are handled by both palletized truck-loading and power-conveying individual cases to the trucks.

Sales are presently being made to about 200 grocery stores in the area.

It is somewhat early to obtain a clear picture of the sales reaction except to say that the response to our products to date has exceeded our expectations. Our 46 oz. can sales of chocolate milk and fruit juice drinks together seem to be averaging about 40 cases (12 cans per case) per week per $12,000 total weekly grocery store sales. Information on table cream sales and consumer acceptance is not available because of the short time we have been marketing this product. However, the grocer's reaction has been quite gratifying. He believes that it is a good item and there has been no difficulty in getting him to stock it in his store.

Concentrated milk of course can have an enormous potential and represents a challenge in production and marketing which many of us will enjoy. We have taken the attitude that most dairy products are beverages; and our canned chocolate milk, concentrate milk, specialty items, such as eggnog, etc., will be marketed right along with the rest of our beverage line, including the fruit juice drinks. An indication of the possibilities in such an attitude is reflected in a number of "Mix or Match" promotions we have conducted where chocolate milk and eggnog were included in four-for-a-dollar sales. The dairy items held their own very well with the fruit juice drinks in these promotions, and we were able to get better mass displays with the entire beverage line than with just one or two items.

The ultimate person we must satisfy is the consumer. We believe Mrs. Housewife will accept the new products in cans if they are manufactured of proper quality, merchandised correctly, and sold to her at a price which reflects the economy provided in a canned product.

Processing and Storage Problems with Concentrated Milk Sterilized by the High-Temperature Short-Time Method

E. O. HERREID[1] AND H. K. WILSON[2]

Research on the high-temperature short-time sterilization of fluid milk products is a new frontier. Ten years ago sterile fluid milk products were laboratory curiosities. They are now appearing in the market places. The interest in these products is increasing. Yesterday 141 people came to our dairy manufacturing building and tasted sterile milk, reconstituted sterile milk, and sterile cream from different sources. The palatability of these products has improved over last year and further improvements can be expected in the future.

Our objectives for research on the effects of sterilizing temperatures on the properties of fluid milk products are to develop products with superior flavor, physical and chemical stability. The regular evaporated milk being produced can not be reconstituted with water to an acceptable glass of beverage milk.

We would be naïve, indeed, if we assumed that the dairy industry will continue in the future as it has in the past. This industry is constantly agitating for new knowledge through research. This leads to progress on all fronts of public and industrial interest. Changes are inevitable and scientific findings can greatly change our industry. Research is the most powerful single influence in our society today as it has been during the past 300 years and our country is now the greatest scientific community in the world. We are part of a rapidly changing world which has seen atomic fission destroy human life and, at the same time, benefit mankind in many ways through applied research.

PROCESSING STERILE CONCENTRATED MILK

In making 3:1 concentrated milk, water is removed from whole milk in the vacuum pan in the same way that it is removed for regular evapo-

[1] Professor Herreid has done pioneering work in the production of sterile concentrated milk. At our 1960 Forum, 960 glasses of his reconstituted sterile concentrate were dispensed at meals. Most people did not distinguish this product from fresh whole milk.

[2] During the past few years, Assistant Professor Wilson has spent the major part of his time assisting Professor Herreid in the experimentation directed toward improving the quality of sterile concentrated milk.

rated milk. The milk is preheated before it is placed in the vacuum pan, and the time and temperature of preheating affect greatly the physical properties of both the fresh and the stored product. The concentrated milk containing 36 to 38 per cent of total solids may be sterilized in a tubular heater, in a plate heater, or by direct steam injection. There are several types of conduction heaters and there are combinations of steam injection and conduction heaters. The concentrated milk may be preheated and heated to sterilization temperatures in from a fraction of a second to two or three seconds and held from a fraction of a second to about fifteen seconds, depending on the temperatures and the types of equipment.

CANNING CONCENTRATED MILK

Concentrated milk or any fluid milk product sterilized by the HTST method must be put into containers, aseptically. Airborne microorganisms must be eliminated as sources of contamination. Furthermore, the containers and their closures and the canning equipment must be sterile beyond all doubt. This is necessary because microorganisms that might accidentally get into cans of milk could spoil them. For this reason every microorganism in the immediate environment becomes an important hazard.

PROPERTIES OF CONCENTRATED MILK

Flavor. Large groups of people have reacted favorably to the flavor of sterile concentrated milk. It can be diluted to an acceptable glass of beverage milk, but experts can distinguish it from regular pasteurized milk. Concentrated milk has a cooked or heated flavor that gradually lessens during storage but it does not disappear entirely. The cooked flavor is inevitable and it can not be avoided when conduction and steam injection heating methods are used to sterilize natural fluid milk products.

Color. Concentrated milk sterilized by the HTST method has the same color as raw milk. The reason that this method does not darken milk is because it passes through the sterilizing cycle in a few seconds or in a fraction of a second depending on the method of heating. Stated more precisely, the slope of the time-temperature line which shows that milk is sterilized is much steeper than the line which shows the brown color development. The more heat resistant bacteria are destroyed before browning occurs or reactions begin that are responsible for browning during heating. The color of concentrated milk remained visibly unchanged for six months at 40° F., but there was a slight darkening after three months at 70° and after three weeks at 100° F.

Advantages. There are advantages of 3:1 concentrated milk over evaporated milk. In regular evaporated milk about 63 per cent of the water is removed and the final volume would be about 44 lb. per 100 lb. of whole milk. For 3:1 concentrated milk about 76 per cent of the water is removed and the final volume would be about 33 lb. per 100 lb. of whole milk. This would result in a weight decrease of 11 lb. per 100 lb. of milk processed. It would not be practical to concentrate milk above a fluid ratio of 3:1 with present processing procedures because lactose would more quickly crystallize out of solution. A concentration ratio of 3:1 was neither an accident nor an arbitrary choice. It was based on a well-known property of milk.

PROPERTIES OF MILK

Milk as it comes from the cow is in an active state. In a biological way it is very much alive, even when it is drawn from the cow without any exterior contamination. There are a few unimportant bacteria in normal milk as it comes from the udder, but there are very important enzymes at work such as lipases, the proteases, the oxidases, the phosphatases, the amylases and possibly others. Milk is synthesized in the cow's udder during a period of about 12 hours. And almost at the same instant it is drawn from the udder, some of these enzymes start breaking down the proteins, fat, and sugar to simpler compounds. These changes may occur slowly at temperatures near the freezing point of milk — but are accelerated as the temperatures increase. They involve complicated molecular reactions which involve ions and atoms, and probably undiscovered particles of matter. Even after milk has been sterilized and when we have destroyed the most heat-resistant spore-forming bacteria as indicated by the usual methods for determining sterility and we think we have inactivated the enzymes, this sterile milk still shows certain peculiar changes. It is in a restless stage. Such changes that occur are not well understood at the present time.

What happens to milk during heating is of great importance. The constituents in milk affected early in the sterilization process are the whey proteins, which are found for the most part in the casein and fat-free portion of milk. These whey proteins are present in milk to the extent of about 0.7 per cent. The most important member of the whey protein group is beta-lactoglobulin and it is affected most by heat. For our purpose we can state that it is in solution in milk, but during heating coagulation occurs, similar to what happens to the white of an egg when it is boiled. The serum proteins in raw milk have globular or coiled shapes, but when they are heated at a certain temperature, their shapes change greatly and they decrease in solubility, and certain of their chemical groups become very reactive. One form of chemical activity is the formation of hydrogen sulfide, and the cooked flavor. Furthermore, certain sulfur compounds, known as sulfhydryl groups (—SH) are exposed at certain points in the protein molecule. These groups (—SH) are the most reactive ones in proteins and are powerful antioxidants that are capable of retarding the development of the oxidized flavor that so frequently occurs in milk. This is the principal reason why market milk is being pasteurized at temperatures as high as 180° F. for 15 seconds. This improves shelf life and preserves the flavor of milk. These heat changes in the whey proteins are frequently referred to as denaturation. They are easy to detect. Ordinary pasteurization temperatures do not affect greatly the whey proteins, but sterilization temperatures change or denature them almost completely.

The other important protein in milk is casein. It constitutes about 2.6 per cent of milk. Casein is very complex and it is associated with calcium, inorganic phosphate, magnesium and citrate. It may be called a calcium caseinate-phosphate mixture. The casein particles in raw milk are very large as compared to the whey proteins, but only the largest ones can be seen under the microscope. They are presumed to have a rounded structure like the fat globules and most of them vary in size from 25 to 300 millimicrons (0.000001 to 0.000012 in.). If we assume that the average size of fat globules in milk is four microns, then we can make a simple calculation and find that the casein particles in milk are about ⅕ to 1/1,000 times smaller than the fat globules. There are about ten trillion casein particles per milliliter of milk as compared to about 3 billion fat globules. These casein particles are very sensitive to heat, salts, and acid. They are held in suspension in normal milk by a delicate balance of electrical charges and are associated with calcium and magnesium. Because the casein particles are stabilized by electrical charges, they are very sensitive to acid development and to changes in calcium and magnesium which always occur in milk at certain seasons of the year. The casein particles quickly come together when calcium and magnesuim increase and break apart when these elements decrease in milk.

The casein particles are more resistant to heat and are not affected at temperatures that change the structure of the whey proteins. Nevertheless the casein particles can be destabilized by sterilization temperatures and they form some kind of network with the serum proteins. This network causes an increase in viscosity, then as more heat is applied, the caseinate-whey protein network visibly separates from the milk system. This is known as heat coagulation.

The effects of HTST sterilization temperatures on the salts in milk have not been studied extensively, but we know that they are affected in important ways. The evidence indicates that heat lowers the amount of dissolved calcium and phosphate in milk. It is probable that both calcium and phosphate become insoluble and are transformed into larger particles. This transformation may be influenced by changes that occur in the calcium caseinate-phosphate complex. We know that if calcium and magnesium are present in excessive quantities, the heat stability of evaporated milk is decreased.

PROBLEMS

Gelation. This is without doubt the number one problem in the commercial production of concentrated milk by the HTST method. It has been stated that the caseinate system in milk is very heat stable, but the addition of small amounts of whey proteins make the milk more susceptible to heat coagulation. It is possible the whey proteins combine with the caseinate in some way to form a complex. Gelation appears to be a form of destabilization but different from that caused by heat alone. A smooth gel may form in a few weeks depending on the storage temperature. It will shrink and whey separates out. In the early stages of gelation, it is possible to break the gel by shaking and it apparently becomes fluid again. But eventually the gel can not be broken to a uniform condition and its structure becomes permanent. Gelation occurs, but not frequently, in regular evaporated milk which is subjected to a much more severe heat treatment than is 3:1 concentrated milk made by the HTST method. This suggests that the more severe treatment of regular evaporated milk changes the protein system in such a way that during heating it passes the critical stage for gelation. This defect can be retarded by sterilizing concentrated milk at about 295° F. for 20 to 25 seconds; however, the body and texture and flavor of the product are impaired by this more severe heat treatment. Gelation occurs also in sterile whole milk but it takes much longer.

We have followed the course of gel development in our laboratory with viscosity measurements. It is not possible, as yet, to give a viscosity value in the storage life of a concentrated milk and state that this is where the product changed to a gel and this is where it was fluid. The transition from a solution to a gel is gradual, depending on the temperature of storage. At storage temperatures of 60° F. and above this transition is rapid. At 100° F., concentrated milk will gel within three weeks while at 32 to 40° F., it can be reconstituted to whole milk after it has been in storage for six months. It is evident that a drastic change in structure of the milk occurs during gelation.

Preheating Effects. Gelation appears to be affected by the preheating history of milk. It is well known that preheating or forewarming milk before putting it in the vacuum pan increases greatly the stability against coagulation of evaporated milk during sterilization. The reasons are not known. Regular evaporated milk develops enough viscosity to hold the fat in suspension and to prevent the solids-not-fat from settling out. This condition is necessary also for concentrated milk sterilized by the HTST method. The viscosity of this product is usually low and for this reason it may be critical in the early stages of storage. During preheating there is an increase in the size of the particles in milk. This involves chiefly the protein particles and the fat is also involved. The size of these particles is dependent, within certain limits, on the time and temperature of heating; the more severe the heating, the larger the particles. Of course there is an upper limit, beyond which they do not increase in size.

In our studies we have preheated milk for 30 minutes at 180° F. and for as little as two seconds at 180° F. Then we sterilized the milks at 285° and at 300° F. and stored them at 40, 70, and 100° F. We determined the relative particle sizes by spinning samples of sterile milk in a high-speed centrifuge, like the Babcock centrifuge, except that it can be made to spin faster and produce greater forces. As this centrifuge was spinning, we took pictures of the settling sediment at different times. Large particles formed a deeper layer of sediment than the small particles. Of course the time of spinning the centrifuge was also considered. We made some curves which showed that as the temperature of preheating was increased, the particles became larger. There may have been changes, also, in the shape of the particles.

We started with raw milk presumed to have casein particles with an average diameter of about 100 mμ. (= about 0.000004 in.), but we found particles in the final sterile concentrate with an average diameter of 2000 mμ. (= about 0.00008 in.). In other words these particles had increased 20 times in diameter, due to preheating, homogenizing, and sterilizing. They had become microscopically visible. These particles were counted and found to be sufficiently numerous to account for all of the fat, casein, and denatured serum proteins. The fat plays an important role in fixing the final structure of the particles found in sterile concentrated milk. When samples of concentrated milk were centrifuged immediately after sterilization, from one-third to one-half of the fat was found with the protein in the sediment. A stable fat-protein union was formed during homogenization. When gelled samples of milk were centrifuged, practically all of the fat was found with the proteins in the sedimented layer.

The microscopic appearance of sterile concentrated milks was observed during gel formation and it was found that the larger particles formed groups of twos and threes and these joined to form larger groups. As these groups grew to form a sponge-like network, their movement was no longer detectable in the microscope. These large particles, formed during gelation, were thrown down very quickly during centrifugation.

We centrifuged whole milks which had been in storage for about two months and were surprised to find that the protein particles had decreased in size during storage at 70 and 100° F., but there were only slight changes at 40° F. storage. This is an example of sterilized milk being in a restless stage. All bacteria had been destroyed as indicated by usual methods for showing their destruction, yet the structure of the protein particles changed. There are also signs of other biological life reappearing in sterile milks during storage, such as the reactivation of the enzyme, phosphatase. These studies are being continued on sterile concentrated milk with hopes of getting some clues concerning the causes of gelation.

The centrifugation procedure is useful in determining the physical stability of milk subjected to various preheating, homogenizing and sterilizing conditions. It can be presented in a mathematical way. The results of our work in this paper have been presented in a very qualitative and over-simplified way.[3]

It is questionable if we can prevent gelation in concentrated milk at elevated storage temperatures and have a product of acceptable palatability. There may be an optimum time-temperature combination for processing and for sterilizing that may retard this defect. The best and most practical combination has not been reported, that is the one that affects the flavor and structures of the product the least and maintains them the longest. Our present experience indicates that the product must be refrigerated during storage and the temperature required will depend upon the duration of storage.

Finally, we may need to revise our ideas about the shelf-life of sterile

[3] For a technical presentation of this material, the reader is referred to papers in the *Journal of Dairy Science* for February and December, 1960 and March, 1961.

fluid milk products. We may be demanding the maintenance of storage qualities that are difficult, if not impossible, to achieve. At 80 to 100° F., fluid milk products quickly develop off-flavors and the objectionable brown color. In fact, this color develops in dried milk powders at high storage temperatures. Insofar as is known, the natural flavors, nutritional properties, and physical characteristics of the more simple foods can not be maintained at high storage temperatures for relatively long periods. This has been emphasized by authorities during the past decade. The logical, simple, and better way is to use refrigeration to preserve, as much as possible, the desired properties of sterile fluid milk products. Undoubtedly physical and chemical stability are associated with flavor stability.

Can Quality of Fresh Concentrated Milk Be Maintained for Long-Distance Shipments?

CHARLES STUBE[1]

My answer to this question is "yes." Fresh concentrated milk is good quality whole milk that has been condensed 3:1 in a vacuum pan. If it is stored for any length of time, it must be refrigerated to prevent deterioration. Normally it is marketed in paper containers.

The foregoing definition is generally accepted for fresh concentrated milk. Rochester Dairy produces many types of fresh concentrates, but not this particular type. Our fresh concentrates are built to suit the buyer, and the concentrate ratio depends upon the desired final product. Some of the fresh concentrates prepared at Rochester Dairy are as follows:

Fat	*Solids not fat*
21.5%	19%
16.25%	14%
26%	22.5%
22%	15.5%
16.4%	14%

We also produce a 32 per cent fresh buttermilk concentrate. Our concentrates are shipped as far east as the Atlantic and as far west as the Rockies. The concentrates are used in the manufacture of ice cream.

The demand for concentrate has been increasing every year as the trend toward larger production in ice cream plants continues. Greater production volume usually results in lower unit costs, so the smaller plants are being closed. Bulk handling, because of its labor-saving advantages, is becoming more important in efficient plant operation. In the past, many plants have changed over to liquid handling of sugar and are now receiving their milk fats and solids in the same way.

Rochester Dairy started manufacturing and shipping fresh concentrate on a large scale several years ago. Since that time the volume of product moving from our plant has risen steadily. During 1960 we shipped over

[1] General Manager, Rochester Cooperative Dairy, Rochester, Minnesota.

200 truckloads of fresh concentrate to various points. The concentrate is shipped in bulk, each load being approximately 35,000 pounds. On a load of concentrate with a 26 per cent fat and 22.5 per cent solids not fat, 260,000 pounds of milk is represented in the fat portion and 90,000 pounds in the solids-not-fat portion.

Transportation is a real factor in long-distance shipments. The hauling cost of shipping a load of concentrate to the East Coast would be $630 in comparison with $4,410 for seven loads of whole milk, or a transportation saving of $3,780 on the same amount of milk fats and solids.

We have had no quality problems on fresh concentrate shipped over long distances. To maintain quality on fresh concentrate, we control three important phases: (1) raw ingredients, (2) processing techniques, and (3) load-out and shipping.

We all know that the finished product can be no better than the raw ingredients that go to make up the final product. The incoming raw milk undergoes a series of quality checks that help to guarantee the quality of the finished product. The checks that are made are as follows: (1) temperature, (2) acidity, (3) direct microscopic count, (4) methylene blue, and (5) standard plate count.

The temperature of all milk coming into the plant is checked and recorded daily. An acidity check is run on each tankload of milk recorded. Direct microscopic counts are run daily on milk from receiving stations and member creameries. Methylene blue tests are run semimonthly on all direct patrons, and standard plate counts are run semimonthly on milk from all Grade A patrons. To produce quality concentrate, we strive for the following conditions: (1) direct microscopic count, less than three million, (2) acidity, .15, and (3) methylene blue, over five and one-half hours.

Over 90 per cent of the milk we receive meets these requirements. The milk that does not is segregated and used for other purposes. A large percentage of the milk we receive from our members is handled by the modern farm bulk method. Six years ago we made a complete conversion from milk cans to bulk in our Grade A plant. In the last few years conversion has also resulted in our having a large percentage of the manufactured milk handled in bulk. Rapid cooling and improved sanitation practices are favorable considerations in farm bulk milk handling. Naturally we are intensely interested in the subject of bulk concentrated milk, as we represent an area where 80 per cent of the quality milk production is surplus and must be transported out of the state.

Milk for fresh concentrate is normally processed as follows:

1. Classified and standardized to 3.5 per cent butterfat
2. Pasteurized 180° F. for 16 seconds
3. Homogenized at 2500 pounds per square inch and cooled to 130° F.
4. Condensed to slightly over 3:1 concentration in vacuum pan
5. Water added to adjust fat to 10.5 per cent
6. The concentrate homogenized and pasteurized to 180° F. for 20 to 25 seconds and cooled to 40° F.

Our method of preparing fresh concentrate varies considerably from the above. We manufacture as follows:

1. Separate the whole milk into 40 per cent cream and skim milk
2. Pasteurize cream at 170° F. for 25 seconds
3. Cool to 40° F.
4. Skim the pasteurized at 165° F. in hot well, 10-minute hold
5. Concentrate to desired ratio
6. Cool to 40° F.

The 40 per cent cream and concentrate are pumped together into a storage vat, where they are agitated and checked by Mojonnier for fat and solids. Cream concentrate or water is added to standardize the concentrate. The concentrate is heated to 145° F., homogenized at 1500 pounds per square inch, and cooled to 34° prior to shipping. All fresh concentrate is stored in cold wall-storage tanks to maintain a temperature of 34° F. Naturally, all equipment used in processing must be in excellent repair and free of any contaminating factors.

To maintain quality during loading and shipping, special precautions are taken in preparing lines and truck for loading. The tanker is scrubbed manually just before loading. After being washed, it is inspected and sanitized. The lines and pump from the storage tank undergo the same treatment before any product is pumped. Certain checks are made on the concentrate before it is allowed to be loaded. They are: (1) acidity, (2) temperature, (3) coliform count, and (4) fat-solids ratio. The acidity must be normal for the particular concentrate being loaded. Temperature must be 34° F. or less. Coliform count should be less than 10/ml. Finally, the fat and solids not fat must be correct. If any of the above are off, the load is held up until the situation is corrected.

We use conventional milk transport trucks for shipping fresh concentrate. No additional refrigeration is provided once the load is in the transport. On long-distance shipments, we expect very little temperature rise — only 2° to 4° under average conditions. Travel time to the East Coast is about 36 hours. All tanks are sealed before they leave our plant so that the contents are protected.

At present Rochester Dairy is not manufacturing a Grade A 3:1 fresh concentrate, but we manufacture many other types of fresh concentrate that are used for manufacturing purposes. We have had no difficulty in maintaining quality in our concentrates in long-distance shipments. The quality of the fresh concentrate is maintained by controlling (1) raw ingredients, (2) processing, and (3) load-out and shipping.

Contamination of a product is difficult to prevent during load-out, transport, and pumping into another plant. The final pasteurization of the fresh concentrate should be done just before final packaging.

We believe the quality of fresh concentrated milk can be maintained for long-distance shipments and, further, that the demand and potential sale for this product will increase substantially.

I also call your attention to the following statements made by men or organizations whose authority is recognized by all the people of the world:

The United States Public Health Service says, "Of all the factors of man's environment, none is more important to his welfare than food. Of all foods, none is more important than milk."

The United States Department of Agriculture says, "Milk does more for the body than any other food. It provides high quality protein, calcium, and vitamins A and G."

The late Dr. Charles Mayo said, "Every person, young or old, should drink milk. Milk contains a large variety of nutritional constituents, and, considering its cost per pound, more food for the money than any other food material available."

A Progress Report on Aseptic Packing and Marketing Milk in Flexible Containers

ROBERT J. GRAVES[1]

Today I am representing two companies of a four-way partnership who joined in a research project in late 1957 to exploit the possibilities afforded by the Tetra-Pak equipment in aseptic packaging of sterile fluids.

These companies included Tetra-Pak of Lund, Sweden, Crown-Zellerbach of San Francisco, and the two companies which I represent today. The Graves-Stambaugh Corporation is a patent development company whose patented processes on equipment include those on sterile processing of milk, developed by Roy R. Graves, and initially used at the plants owned and operated by Foremost Dairies at Stanwood, Washington, and Ridgeland, Wisconsin.

Real Fresh Milk, Incorporated, of Visalia, California, a licensee of Graves-Stambaugh, is now entering its tenth year in aseptic processing and packaging of dairy products for worldwide distribution.

The missions of the four partners in the experiment were as follows:

1. The Tetra-Pak Company of Sweden, already in production on a machine which formed, filled, and sealed fluids in a flexible paper and polyethylene container, to provide modified equipment.
2. The Crown-Zellerbach Corporation, manufacturers of the paper for the Tetra-Pak containers, to develop a laminated paper which, when filled and sealed by the Tetra-Pak machine, would be non-breathing in character, would withstand shipment, and could be packaged in cartons that could be moved through normal channels of transportation.
3. The Graves-Stambaugh Corporation to develop a process for pre-sterilizing and aseptically filling the container with a pre-sterilized product.
4. Real Fresh Milk, Incorporated, to adapt the combined operation for practical production, and to engage in test-marketing the aseptically packaged products.

[1] President, Real Fresh Milk, Inc., Visalia, California.

To carry out the missions, the Tetra-Pak Company produced a modified Tetra-Pak filler and sealer with a heat-sealing unit capable of what is known as "impulse sealing" as differentiated from their standard "constant heat" principle, in order to effectually seal through an aluminum foil laminated paper.

The Crown-Zellerbach Corporation produced a laminated 90-pound paper with one-mil aluminum foil and an inner ply of two-mil polyethylene, which was non-breathing. This paper was put up in rolls of 7500 units per roll. Further, they developed several one-way fibre containers for these Tetra-Pak units which could be automatically packaged on the Tetra-Pak machine, and shipped either on a palletized basis for controlled distribution, or encased in sealed sleeves for transporting by common carrier.

The Graves-Stambaugh Corporation evolved a method of pre-sterilizing the unrolling paper web with a fogged-on chlorine spray, the maintenance of this sterile paper performed by a combination of bactericidal lamps plus an atmosphere of sterile nitrogen. The filling and sealing of the pre-sterilized liquid in a tube formed by the paper is done in an atmosphere of sterile nitrogen gas.

Experimental work began on this project in 1957. The first experimental machine was delivered to Real Fresh Milk at Visalia for perfecting the process in early 1958. Subsequently, the experimental equipment was replaced by production equipment supplied by Tetra-Pak, modified in accordance with recommendations of the joint venturers.

Real Fresh Milk began test-marketing sterile fluids in the form of fruit juice drinks in September of 1958. This experiment was done with the assistance of the Bireley's Division of General Foods, and their distributor in the Oakland-San Francisco area. That company had been searching for a disposable package for use in schools where refrigeration and inventorying of refrigerated drinks was a problem, and where previously they had been distributing in cans.

A cost comparison of these two methods reveals that the eight-ounce can unit plus the prorated portion of the case, was \$.03243, whereas the eight-ounce sterile Tetra-Pak, plus the prorated portion of its case, was \$.01399, a savings of 56 per cent. With the addition of pallet prorations, and strapping for shipment on this basis, savings approximated 45 per cent. Production royalties, machine amortization, and processing costs brought this eight-ounce unit up to \$.02104 at the machine speed of 72 per minute, or 25.2 cents per dozen.

A similar operation, using aseptic packaging in eight-ounce cans at the Real Fresh Milk plant cost 50.4 cents per dozen at the same machine speed. A comparison of the eight-ounce unit on a non-palletized basis, by packaging in a fibre sleeve for common carrier transportation, does not reflect so great a saving. The unit cost per eight-ounce unit in Tetra-Pak in sleeves is $.02626 or 31.5 cents per dozen, a savings of 18.9 cents per dozen over cans.

These cost comparisons are based on mechanical packing of eight-ounce cans at the equivalent speeds with the Tetra-Pak machine, reflecting hand-packing costs of the three 18/8-ounce tetrahedron containers into the outer sleeve, without the assistance of jigs or mechanical packing. A comparison with higher-speed aseptic packaging can units would reflect a lesser saving, depending upon the machines being compared.

Preliminary market analysis revealed that there were a number of opportunities for introducing a sterile Tetra-Pak container into areas in which Real Fresh Milk already had established outlets for aseptically packaged dairy products in cans. Since the most successful operation for the Tetra-Pak package for FRESH products had been in areas where the user could be educated in the appropriate method of opening, or in which an operator opened the package for the customer, the first avenues of distribution were obvious.

These included schools, sporting events, theatres, and similar areas of controlled distribution in quantity, including the Armed Forces.

The Armed Forces, and particularly the Navy, had long been searching for a cheaper package than a metal can to provide certain features. First, portion control — it has been the custom of the Navy to obtain sterilized dairy products in one-quart and three-quart containers, transferring their contents in the galley to a pitcher with attendant loss, and lack of portion control. Second, a single-service disposable unit at a favorable cost to offer a means of serving from the "chow line" a sanitary package which could be opened by the individual user with no possibility of contamination prior to use. This disposable package eliminated the need for drinking cups and their attendant washing or disposal. Also, the savings in weight, approximately 11 per cent, was reflected in transportation costs.

Storage ashore or aboard ship on a nonrefrigerated basis would be comparable to sterile milk in cans, and cheaper than storage for frozen or fresh milk or frozen concentrate.

The Navy began a trial, using this aseptic package for milk, on its

Military Sea Transportation Service vessels in February of 1960. Five vessels carrying troops and dependents between San Francisco and the Far East used the package for a period of trial as a substitution for the sterile product in cans. On July 11, 1960, the U.S. Navy Subsistence Office, authorized West Coast stock points for a broader trial for this product, purchased through the Quartermaster Corps, under U. S. Department of Agriculture inspection, for issue to afloat consumers. Since that time, sterile Tetra-Pak units have been used by 30 of the Navy ships departing from San Francisco, Los Angeles, and San Diego. Consumption each month has increased as acceptance of this new package and satisfactory usage were reported.

Progress to date, although encouraging, has not been without problems. Difficulties in opening have had to be conquered by education through poster-type advertising, at the point of sale or usage.

Post-contamination problems encountered in the early test-marketing were traced to two factors: Pre-oxidation of the polyethylene-lined paper rolls in storage, resulting in failure of the seals of the packages after extended storage at high temperatures. This defect was cured by storing the paper rolls at temperatures which precluded pre-oxidation. Then the shipping cases failed to withstand the rigorous handling of common carriers; and stronger cases, together with cushion fibre inserts, were developed to overcome this problem.

Recently a new combination shipper and container to replace the two units now being used has been developed which the first tests show will be superior to the method now used, and less expensive from a packing standpoint.

Further research by Crown is still in progress to develop outer cases for these units to further reduce packaging and handling costs and prevent damage of the interior cartons under adverse handling conditions. Research is being carried on to develop jigs for loading the cartons from the packer into the sleeve, which is now being hand-packed.

The most recent major development in overcoming the consumer acceptance of this package on a domestic market, has been the perfection of a wrapped, pointed, polystyrene straw which is used to pierce the package without the difficulties encountered in tearing off a corner to open. This method has now been used successfully in the theatre trade in California and Arizona, and in such controlled distribution as sporting events in the San Francisco Bay area, and is on a trial basis in a chain cafeteria in California. Preliminary results from these marketing channels indicate that this method of opening will result in a much wider consumer acceptance than has previously been possible.

Successfully packaged and test-marketed products to date include: Sterile Milk, flavored drinks, half and half, whipping cream, juices and juice concentrates. Other sterile fluids are in the process of being tested in storage.

It is now feasible to aseptically process and package some pre-sterilized fluids in this form of flexible container on a basis which will result in a non-breathing package which can be stored and transported through normal channels of trade, without refrigeration. Undoubtedly, future research will provide for more conventional packages embodying desirable features not now present in this somewhat unusual pyramid-type package.

At the present time, however, this unit provides the only flexible, non-breathing container for sterile fluids capable of being aseptically packaged, shipped, and stored in present-day commercial channels.

Why Aseptic Canning in the Dairy Industry?

FRED M. JOHNSON[1]

Following World War II, there were sufficient pressures and trends within the food industry to stimulate enterprising food equipment and process engineers toward the development of imaginative new techniques which would make available to the consumer new food products in a convenient form and would improve the quality of certain existing products long in need of such improvement. It was to this task that Dole Engineering Co. directed itself, with the belief that a vast field of application existed were the processing virtues of short-time, high-temperature sterilization to be made commercially available to industry. The results of these several years of development work have in no other way been as important nor possessed greater potential than as applied to the milk industry. Today there are over fifty installations of the Dole equipment in the United States and Europe, and the use of the aseptic canning method is rapidly expanding. Of interest to this group is the fact that the majority of these installations are in use in the dairy industry for the sterile processing of milk and milk products.

Since the basic and revolutionary work of Nicholas Appert and Louis Pasteur in the field of food sterilization there has been a continuous effort on the part of food scientists successfully to combat the perishability characteristic of milk. The innovations of Gail Borden and others in the fields of sweetened condensed milk and then evaporated milk were stimulated by the great demands of the Civil War and then by the Spanish-American War, and were the remarkable forerunners of today's greatly advanced milk technology.

These early products confirmed in commercial practice that an acceptably palatable milk product could be derived from a concentrated form. Further, that a product could be sterilized or bacterial growth inhibited so that the resultant product could be kept for extended periods of time without spoilage, and that a major percentage of the original nutritive

[1] James Dole Engineering Company, San Francisco, California.

values of this superior food source could be retained in such a concentrating and sterilizing process.

In the evaporated milk products the undesirable flavors imparted by the long sterilizing process were most obvious, but improvements in flavor quality were long delayed because engineering methods, processing techniques and control instrumentation were not developed to a point enabling replacement of the conventional retort operation.

Accordingly, scientific advances in beverage milk were directed toward fluid milk, and innovations of pasteurization and homogenization as departures from the raw milk form were tremendous strides in improved milk quality.

In more recent years forces and influences have brought into the milk industry developments and resultant products which stand to change the entire picture of the industry. The approach by dairy science is now one of attacking the perishable nature of milk products by producing sterile products comparable in flavor characteristics with the fresh, and possessing stability values necessary to provide extended shelf life. Organoleptic aspects now have a primary place in today's dairy research directed toward nonperishable products with fresh product flavor and extended stability the ultimate goals.

The development effort directed toward sterile milk products has been accelerated as a result of increasing costs of marketing perishable products, by the increasing problem of surplus milk supplies, and by certain trends in consumer buying habits associated with a requirement for increased *convenience* in food products generally.

In recent years major strides have been made in milk research by universities and industry representatives relating to the sterile processing of both fluid and concentrated milk, and manufactured milk products. Much of this work, and the subsequent translation to commercial operation in industry, has been made possible as a result of important engineering design and process developments in the field of aseptic canning equipment and short-time, high-temperature heat exchange techniques. These necessary tools have proceeded from the state of laboratory apparatus to today's broadly accepted commercially designed and operating units of equipment possessing a high degree of technical advance.

The question is asked, "Why aseptic canning in the milk industry?" With the trends for product change and improvement which exist in the milk industry, it appears that one of the primary lines of approach is that of producing a fresh tasting sterile and stable product by high-temperature, short-time methods, and to preserve the virtues of the HTST method, an aseptic canning process is a necessary adjunct. Earlier work by Ball and others showed that in the thermal sterilization of canned foods, a short process at high temperature produces a finished product of better flavor, color and texture than an equivalent process at low temperature. Our work with the aseptic canning process was undertaken with the object of developing equipment of simple design for operation with various types of heat exchangers available for the HTST sterilization of fluid products — equipment designed to capture the virtues of so-called "flash" sterilization.

The milk technology involved in many phases of aseptic canning can be complex. Destruction of spoilage bacteria is only a single aspect of consideration. Attendant are also the problems of stability and gelation, of enzymatic action and biochemical interactions, of viscosity changes and the direct flavor effects of heat. However, great progress has been made and continues to be made. The increasing acceptance of the aseptic canning process as a milk treating method has placed numerous installations in the laboratories and pilot plants of universities and industry where continuous progress is indicated in advancing the work in this field of technology. And as gains are made and results determined, the accomplishments are transferred to commercial operation so that each month sees new milk products of sterile, nonperishable nature on the market, with the promise of more to come in the near future.

This is a broad movement underway which is bound to have an increasing influence upon the thinking and planning of the milk industry. The factors prompting it are all in place. However, a broad acceptance of the process in the vast volume areas of milk usage, such as a concentrated milk for beverage purposes, will face many obvious barriers. Milk technology must develop products which the consumer is willing to substitute for existing and traditional products; flavor, keeping, and texture characteristics must be acceptable. The price of the end product in the market must be attractive. The legal barriers established by the numerous regulatory bodies must be removed. And members of the milk industry must first recognize the trend of change and become part of it.

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