Throughout the fluid milk industry, processors are currently studying the effect and the necessity for ultra high temperatures (UHT) in pasteurizing and the use of Flavor Control equipment with relation to their Grade A bottled milk market. Undoubtedly, the installation of machinery to accomplish either or both of the above by a competitor will result in any plant giving serious consideration to the purchase of similar equipment.

It, therefore, behooves milk sanitarians, laboratory technicians, pasteurizer operators, as well as dairy machinery suppliers to develop an understanding of UHT and flavor control equipment and what it will accomplish for the industry.

The two should be considered together, for as research and field experience have shown, optimum flavor control cannot exist without steam treatment, and with steam treatment UHT is available.

To properly understand a process and the equipment used, it is necessary to know why it was developed. To understand the net result to the dairy farmer to produce, in as sanitary a manner as possible, milk that has good flavor and low bacteria count. It must be cooled and maintained cold until picked up for delivery to the plant.

Good flavor is the one factor over which the Grade A producer has only limited control. Naturally, it is dependent to a great degree on the cows diet. In the past, its control has been based on pasture selection and feeding schedule. This is most difficult, for the diffusion rates of the numerous feed and weed flavoring substances and their retention in milk vary so widely that effective preventative feeding and milking schedules are almost impossible to work out for the entire year. Furthermore, the milking cow is often enticed by the most noxious things, even when she is knee-deep in excellent pasture.

Unless the processor can standardize the flavor, his product will appeal to the consumer at times and repel at other times the taste acceptance of his customers. Milk is but one of many products available to the public. In competition, millions of dollars are invested in the soft drink industry, coffee, tea, etc. These people are leaving no stone unturned to improve and standardize the flavor of their product to attract the buyer.

The chosen task of the processor is to accept farm produced milk in sufficient quantities to fill the demands of his customers; to process it in such a manner as to result in its retaining a high quality under present marketing methods until consumed; and to be attractive enough to compete for the consumers' money. Under present processing methods, milk is still a highly perishable product.

The population trend to the suburbs, along with the rapid development of supermarkets, has resulted in a great many families resorting to once a week buying. Centralization of milk processing plants leading to expanded marketing areas results in greater hauling distances. All in all, a great deal more time is elapsing between production, processing, and consumption than was the case a few years ago.

Therefore, the processor must accomplish the two things for which UHT and flavor control equipment was developed. To understand the net result to the milk itself, we must study the published results of many researchers from all parts of the country.

In solving the problems, we cannot create greater ones by changing the product so as to create a resistance from the ultimate milk consumer. That is, UHT must be so controlled as to not develop an objectionable cooked or carmelized flavor. It has been determined that less cooked flavor will develop at 160°F. for 15 seconds than at 145°F. for 30 minutes (3,8). This indicates that cooked flavor is more a function...
From the condensed milk industry, it was found that the vacuum pan gave considerable relief. Experiments included blowing hot air into the pan, and injecting live steam (7). It was found that steam injection was the most efficient.

Successful equipment has been in use in the butter industry using this principle for some time. Patents for deodorizing equipment are on file as early as 1935 (9). Some of the same equipment has been tried with varying degrees of success in the Grade A field. Side results from rough treatment, however, resulted in further searches for equipment to do the same job in a more gentle fashion. The need for such equipment has been very intense in order to standardize the flavor of bottled milk. Consumers are more critical than ever and milk consumption decreases in almost a direct proportion to the intensity of off flavor present.

As to the incidence of this problem in the market milk supply, the fact is that 44% of all the milk samples used in Collegiate Dairy Products Judging Contests from 1946 to 1954 contained defects listed as feed or weed (9). This gives us the reason for the rapid development of flavor control equipment. Pasteurization has not been able to cope with the problem, and it is also true that some of the feed flavors come from the most economical feeds. Another survey revealed off flavors due to feeds in 75% of the samples of pasteurized milk collected from eight cities (2).

The principles learned in the condensed milk and buttermaking industry can be adapted to fluid milk processing, and several machinery manufacturers are now offering equipment designed to help the processor.

Some of these systems employ vacuum only, others employ steam treatment followed by vaporization. Some utilize a single vacuum cylinder, locating it downstream from the raw side of the regenerator, others are downstream from the flow diversion valve. Two cylinders have been used, locating one downstream from the raw regenerator, the other downstream from the flow diversion valve. Another system, uses two cylinders, both downstream from the flow diversion valve. The No. 1 cylinder is used as a steam treatment cylinder and the No. 2 cylinder as a vaporizing cylinder. There is little wonder at some of the confusion existing in the minds of processors as to methods and equipment to employ. Naturally, with these various systems offered, an installed cost differential is anticipated as some of them include a great deal more equipment than others.

Research by many different investigators has led to the following general conclusions. Many of the flavoring substances are volatile at temperatures under 200°F, and can be distilled from milk (9). Some
are soluble in fat, some are soluble in the skim milk; and others are made up of several components, some soluble in water, others in fat. Then there are the flavoring chemicals which are almost insoluble and some are non-volatile. It has been shown that volatile flavoring substances and those which are soluble can be removed by vaporization, and those which are more or less insoluble require more thorough treatment such as steam distillation which both washes and vaporizes.

It has been established by research and by observation of commercial installations that more complete removal of feed flavors and a more uniform product results when steam is used with the vacuum treatment than when vacuum is used alone. This was confirmed by Dr. William Roberts (10) of the University of North Carolina. He reported to the Milk Industry Foundation meeting in 1956, as follows: "All the machines reduced the intensity of feed flavor present in milk. The improvement in the flavor scores was related to the intensity of steam treatment. As the amount of steam treatment increased, the amount of off flavor removed increased. Vacuum treatment alone does not appear to remove the quantity of feed flavor desired by the Dairy Plants."

Dr. W. L. Dunkley (1), of California, reported at the Milk Industry Foundation meeting in San Francisco as follows: "The deodorizing treatment is largely a steam distillation process. Its effectiveness in removing tainting substances depends on such factors as volume of steam used, concentration, solubility, and volatility of the substances in the fat and aqueous phases of the milk as well as between the milk and the vapor surrounding the milk film or droplets." He also said, "Undoubtedly, any deodorizing treatment will effect some improvement in most milks with feed flavor."

Here are two separate and distinct problems; first, the need for higher temperature of short duration to provide greater killing power, reduce oxidation, and retard rancidity — the net reason to obtain longer shelf life and a high quality product. This must be accomplished in such a way to keep cooked flavor to a minimum. Second, by steam washing and distillation under vacuum it is hoped to standardize the flavor, eliminating, in so far as possible, the feed and weed flavors commonly encountered.

The most modern UHT and flavor control devices must accomplish these two objectives in a single system and make it possible to install it as an accessory to any HTST unit. In fact, the opportunity of UHT just ahead of a vacuum vessel where instant vaporization and flashing will take place can accomplish the requirements of both. The high temperature time phase can be limited by the distance the infuser or injector is located ahead of the vacuum vessel.

Whether the time required as per Dr. Dunkley's statement is available for diffusion and the establishment of the equilibrium between the fat and aqueous phases, as well as between the milk and the vapor surrounding the milk film or droplets, will be determined undoubtedly by commercial installations and further research.

It is generally understood that Ultra-High Temperature (UHT) pasteurization has as its lower limit 194°F. for one second of holding time. There is no set upper limit, but UHT ranges up to the sterilization point.

The processing problems to be solved by adequate equipment have to do with heating, cooling, and vacuum treatment. Heating may be accomplished by usage of heat exchange surface as exemplified by plate equipment or the relatively new jacketed tube types. These are particularly designed to obtain higher temperatures than practical in conventional plate equipment through the use of special heat exchange surfaces and using steam as a heating medium. Then, of course, there remains direct steam injection into the milk flow. This may well prove the most widely accepted method for various reasons, such as economy of installation, and the previously mentioned requirement of steam washing and distillation to effect ultimate flavor control. A remaining reason, and just as important, is the requirement that the product be neither diluted or concentrated. By injecting steam into the milk to raise its temperature, then removing it in a vacuum vessel to effect the removal of off flavors, the exact composition of milk can be maintained with proper automatic controls. The USPHS requires that milk shall not be diluted. Reasonable concentration, however, is not a Public Health problem, but concentration is very important economically to the processor. The cost of necessary controls to prevent concentration as well as dilution is returned very quickly in product saved.

Actual control of concentration and dilution can be attained through the installation of the Taylor Instrument Company Ratio Controller. It will maintain a set temperature differential between milk entering the equipment and leaving it. This temperature differential means that the heat added through steam injection is exactly equal to the heat removed in the vacuum cylinder corrected for whatever heat is lost through radiation from the surfaces of the equipment itself.

The thermodynamic principle making this type of control possible is comparatively simple. The heat added by the steam results in a milk temperature increase. Upon flashing in the vacuum vessel, vaporization occurs, removing enough latent heat to cause a lowering of the milk temperature. By controlling the vacuum level, the temperature of vaporization and
latent heat of vaporization is controlled. With a steady flow of milk, a thermodynamic balance (removing as much vapor as added) is evidenced when the milk temperature loss in the vaporizing vessel just equals the temperature gain from the steam treatment. An additional correction is made for radiation losses.

Control is maintained through the Ratio Controller. By means of sensing elements, it lessens the vacuum when the milk temperature is too low (thus raising the temperature of the product leaving) to prevent concentration. On the other hand, if the temperature is too high, indicating that dilution is occurring, the instrument, which is wired into the Flow Diversion Valve circuit, causes the milk to be diverted. When set (correct) temperatures and vacuum levels are re-established, the flow diversion valve moves to the forward flow position automatically. Proper operation is continuous and automatic.

In attempting to describe equipment now in use, I will confine myself to that manufactured by The Creamery Package Mfg. Company, as I am more familiar with it. Much of the following is applicable to equipment of other manufacturers. Different systems and models are available to satisfy the varying needs of the industry. These include equipment ranging from vacuum treatment only to steam-vacuum treatment apparatus, and in sizes from that required by the small processor to capacities of 50,000 lbs. of milk per hour.

In general, these units are installed in a standard HTST unit downstream from the heater section and Flow Diversion Valve and ahead of the pasteurized regenerator section down. We recommend that homogenization follow the vacuum treatment in order to assure optimum stability of the fat emulsion.

The product flow when using our system with steam treatment is from the flow diversion valve through a vacuum breaker (to prevent the possibility of pulling a vacuum on the holding tube through the flow diversion valve and lessening the holding time during diverted flow) and to the steam infuser or the atomizing cylinder, as the case may be.

The steam is introduced in such a manner as to result in intimate intermingling of the vapor and milk droplets to obtain the maximum effect of steam treatment without damaging the product. The maximum temperature is attained and maintained for only the brief period necessary for the milk to flow through a special designed pressure control valve into the second or vaporizing cylinder. This interconnecting line between the first vessel and the pressure control valve constitutes a holder at the maximum temperature for which the holding time can be calculated. At the pressure differential valve, the pressure is instantaneously reduced to the controlled vacuum and flashing or vaporization takes place with the resultant cooling.

The time of vaporization is a function of the size of the second vessel and the quantity of product flowing. Adequate volume must be allowed under this vacuum treatment for the more stubborn flavors to be removed. The milk enters the vaporizing cylinder through tangential opening near the top and swirls around the sides as it drops to the bottom. The vapors and non condensibles are removed from the top of the cylinder through the condenser. This can be either a standard plate type unit installed as a section of the HTST press itself, or a side arm condenser. The milk is removed from the vaporizing cylinder by a centrifugal pump and moved downstream to the homogenizer or the pasteurized regenerator inlet, as the case may be.

There are several factors in the process which should be of particular interest to an inspector:

1. There must be no pressure or vacuum changes transmitted to other phases of the HTST unit which will affect the holding time or the pressure relationship of raw to pasteurized product in the milk to milk regenerator.

2. Dilution of milk must not occur.

3. Steam from the boiler which contacts the product must be free from oil, rust particles and other impurities. Impurities enter the steam through carry-over of boiler water into the steam lines. Volatile amines used for protecting condensate piping from corrosion should not be used in steam systems connected to this type equipment. Those impurities which are dissolved in the boiler water can be eliminated from the steam by proper operation of the boiler, proper treatment of the boiler feed water, and by effective use of steam purifiers or separators.

Boiler feed water control should be under the supervision of a firm specializing in this service and their recommendations followed. Toxic material should not be used in boiler compounds.

4. Various types of condensers are used, including plate type and direct water or side arm type. With the latter types, precautions must be taken to prevent contamination of the milk with the condensing water.

In conclusion, it might be well to point out that with all the research that has been done on UHT and flavor control, it is the actual commercial installations that are establishing the proof of their ultimate value to the industry. It is conceivable that a new concept of pasteurization and milk treatment has been initiated. Problems will be encountered and solved. Without doubt, a great deal of the credit will go to the local sanitarian or public health inspector.
References


Special Service Article

SIMPLIFIED BACTERIOLOGICAL SCREENING PROCEDURES*

Editors Note: This article is of special interest to our readers since it discusses the use of several innovations in bacteriological procedures which differ from the standard agar plate method, so commonly used. Further, it illustrates the fact that the Association's Committee on Applied Laboratory Methods is alert to new developments and wishes to keep our membership informed.

While the agar plate method has long been the standard procedure used in dairy and food bacteriology, other methods involving the use of both solid and liquid media are playing an increasingly important role. The Astell Roll Tube technic, the Bacto-Strip method, and the Millipore Filter procedure are being studied by the Applied Laboratory Methods Committee to determine their applicability in the dairy and food laboratory.

Astell Roll Tube Technic

The Astell Roll Tube technic has been used extensively in European countries but is still somewhat of a curiosity in the United States and Canada. The advantages of the roll tube method have long been known. As far back as 1922, Professor G. S. Wilson strongly urged the adoption of the procedure. Prouty and Bendixen, in 1944, further emphasized the advantages of this procedure. Its widespread use, however, was hindered by the lack of proper equipment. The Astell equipment first appeared on the market in 1949. It has been subject to several improvements in subsequent years. The apparatus, as it is used today, consists of Roll Tube bottles, bacteriological seals or stoppers, spinner, water bath, and a colony illuminator and counter. The Roll Tube bottles have an overall measurement of 25x75 mm., with an effective inside surface area approximately half that of a standard Petri dish. The bottles have a centralized depression in the base. The bacteriological seals or stoppers are specially designed to vent automatically when the bottles are heated and provide an airtight seal when pressed down. The electrically operated spinner has seven positions, any one or all of which may be used at one time. A multi-jet cooling device is an integral part of the spinner and causes rapid setting of the agar medium in an even film after spinning for a minute or less. Bottles may be inserted on, or removed from, the spinner while it is in motion. The colony illuminator gives indirect shielded light and provides clear illumination of the colonies.

The actual technic consists in inoculating 0.5 ml. of the liquid to be tested (or a dilution thereof) into the bottle containing 4.5 ml. of melted and cooled sterile agar and then placing the inoculated bottle on the spinner. Spinning is continued until the agar has solidified in an exceedingly thin film on the surface. The neck and bottom of the bottle are designed to eliminate any slipping of the agar film. Inoculated bottles are then incubated for 48 hours in an upright position and the resultant colonies counted on the colony illuminator.

The Roll Tube equipment has been in use in this laboratory for nearly two years. Extended experiments have been carried out to compare results using...