



## Heating Methods for Ultra-High Temperature Pasteurization

By Michael Campbell

The move is on for ultra-high temperature (UHT) pasteurization, which will extend the shelf life of milk and other dairy products. UHT pasteurization is being used because consumers are buying more dairy products in bulk, dairy operations are becoming larger, and population expansion is increasingly causing consumers to be located in more remote locations throughout the world.

Traditionally, milk is pasteurized at 180-185°F (about 85°C) and refrigerated. Other dairy products are commercially sterilized by subjecting product to temperatures in excess of 100°C, and then packaging it in airtight containers. The basis of UHT is sterilization of the product before packaging, *then packaging it in pre-sterilized containers in a sterile atmosphere.* Processing dairy products in this manner, using temperatures exceeding 135°C, permits a reduction in the required hold time to 2-to-5 seconds, and yields a shelf stable product that can be stored for extended period of time at ambient temperature.

Some examples of food products processed under UHT conditions are:

- Liquids such as milk, juices, yogurts, cream, and salad dressings.
- Foods with small particulates like baby food, soups, sauces, and stews.
- Soy based products in order to inactivate bacteria and reduce off flavors.

The traditional problems or difficulties in using a UHT process have been:

- Sterility: The complexity of the equipment requires more highly skilled operators to maintain sterility throughout the aseptic process.
- Particulate Size: With larger particulates comes the danger of overcooking of the product surface.
- Product Quality: Heat stable lipases or proteases can lead to flavor deterioration. In a number of cases flavor deterioration has caused a more pronounced cooked flavor for UHT milk as an example.

A major consumer complaint about UHT products has always been the so-called unpleasant “cooked” taste and sometimes-brown color of the finished product. This is understandable when we remember that dairy products in general, and specifically milk, are a colloidal mixture of water, lipids, carbohydrates, and proteins. When the mixture is heated under pressure to ultra-high temperatures, the protein structure is altered in such a way that some of the proteins are denatured and off flavors or browning can occur.

The conventional method for heating products to ultra-high temperatures has been to use indirect heating such as 1) plate and frame heat exchangers, 2) tubular-type heat exchangers such as shell and tube, or 3) scraped surface heat exchangers. The other current method for UHT production is steam infusion.

The goal of the equipment manufacturer today is not only to design equipment that

can process product at increased product flow rates (over 35,000 liters per hour), operate continuously for more than 20-hours a day, and be easily inspected and cleaned, but also to design equipment that can minimize off flavors and browning.

## **Current UHT Cooking Methods**

### **Indirect Heating**

With this method the heating medium and product are not in direct contact with each other. As mentioned earlier, the types of heat exchangers are plate and frame, tubular, and scraped surface. The advantage of using these types of exchangers is that you do not need culinary steam since the two media are kept separate. However, each type of exchanger has its own disadvantages.

- **Plate and Frame Exchangers:** While they are typically easy to inspect and take up less floor space than other types of indirect exchangers, they are limited by gasket temperatures and pressures. In most cases the EPDM gasket is limited to a maximum 160°C. The plates, while easy to take apart, can over time become fatigued as they flex from the constant high temperature steam and lower temperature product passing over the contact surface. Liquid velocities are usually lower for a plate and frame exchanger arrangement and as such can lead to uneven heating and potential burn-on and browning.
- **Tubular Exchangers:** While they have fewer seals and therefore do not suffer as much from gasket limitations or plate fatigue, they typically take up more floor space and are not easy to inspect. Heating may be more uniform, however browning or burn-on is possible because of the large surface area required to achieve the desired set point.
- **Scraped Surface Exchangers:** This type of exchanger forces product

through a jacketed tube in which a set of rotating blades is constantly moving product from the outer walls toward the center. The product is more evenly heated and there is less opportunity for product browning or burn-on. Scraped surface exchangers are also more suitable for highly viscous products and products containing particulates. A general negative has always been the time and cost required for inspection and maintenance of this equipment.

A final point concerning indirect heat exchangers is that while they do a good job of heating product at a fixed liquid flow rate, they suffer when the liquid side flow rate varies. The potential for burning increases as the liquid flow rate decreases.

### **Steam Infusion**

The general concept is to take the liquid product stream and have it pumped at a higher pressure through a distribution nozzle into a chamber filled with slightly lower pressure, culinary quality steam. This system is characterized by cascading a small volume of product through a large steam chamber. The product then collects at the bottom of the chamber and is fed forward via a timing pump.

Product temperature is generally controlled by pressure. Additional holding time is accomplished through the use of hold tubes, plate and frame exchangers or tubular exchangers. This is followed by flash cooling in a vacuum chamber where all added moisture is removed as needed. Variations of this method involve 1) pre-heating the product to a desired set point before the addition of direct contact steam, or 2) using the steam infusion method first followed by flash steam removal and perhaps reheating to a uniform set point.

All of these steam infusion methods accomplish the same thing:

- Instantaneous heating and rapid cooling.
- Lack of overheating or burn-on.
- Heating of low and high viscosity products.
- Use of variable product flow rates.

The negatives of steam infusion are:

- **Size:** The infusion chambers take up a sizeable amount of useable production floor space.
- **Sanitation:** These systems are not easily cleaned.
- **Capital Outlay:** Units require high, initial capital investment.
- **Operations:** A fairly skilled work force is required to monitor pressures, feed pump flow rates, etc.
- **Need for a Timing Pump:** Added equipment and operating cost.

## **Direct Steam Injection**

### **More than a Viable Alternative**

Like steam infusion, Direct Steam Injection uses culinary steam to quickly heat a food product to the desired UHT temperature. Direct Steam Injection blends the liquid stream with the higher pressure steam using multiple orifice injectors, static mixers or venturi type injectors. The key is to get the product to quickly absorb all the steam energy and elevate its temperature as quickly as possible. *Unlike steam infusion it does not require a large chamber filled with steam with a higher pressure liquid cascading through it to achieve the quick heat transfer of steam and liquid.*

The immediate advantage of this type of mixing is that the mixing chamber isn't much bigger than the liquid transfer piping. The overall assembly has a minimal foot print and the mixing chamber itself is

especially small and easy to clean or inspect. Often the chamber requires no more than opening three quick release clamps to remove the device from the process line.

Because the steam has intimate contact with the product, the Direct Steam Injection method maximizes heat transfer. Another important feature is that the same system can, for the most part, process a wide variety of slurries to a desired set point. Some systems, depending on their designs, can even process particulates with little or no product degradation.

Another advantage is that Direct Steam Injection systems are available in a range of sizes capable of handling product capacities from 240-liters/hour to +20,000-liters/hour. Direct Steam Injection systems also require low capital investment, potentially half as much as any other method being considered.

The main disadvantages to using Direct Steam Injection or even steam infusion are:

- Steam injection like steam infusion requires the use of culinary steam.
- **Dilution:** Added moisture must be removed using an atmospheric or vacuum flash chamber. Depending on product specifications, this can be minimized or eliminated by preheating upstream of the steam injector.
- **Sanitation:** Current 3A standards call for COP on steam injector systems so a backup unit or removable spool piece should be considered.

### **Test Results**

One manufacturer of Direct Steam Injection systems and an early pioneer in Sanitary Direct Steam Injection Heating, Pick Heaters, regularly tests a variety of food products to confirm cook temperature can be achieved and maintained while maintaining product integrity..

Recently a series of tests were conducted on whole milk with 4.5% butterfat to determine whether UHT temperatures could be achieved without browning and off flavors. Using 140-psig steam and liquid pressures of 100-psig, their Direct Steam Injection system was easily capable of a 40°C temperature rise when the product was preheated to 95°C. The product retained good full-bodied mouth feel, no browning and no strong burnt smell typically found in a UHT process. And while there was a little filming on the injector, it was quickly cleaned using traditional CIP methods.

### **Conclusion**

The smaller direct contact steam injection system offers a number of important advantages over the other UHT methods being used today. Direct Steam Injection is more than a viable alternative for UHT processing, and should be given serious consideration.

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With over 30 years experience working in Research and Service, and concentration in the benefits of direct steam injection for starch based products, Campbell has worked with NCSA, PMCA, AACT and other food organizations to promote the Pick Sanitary Heater and its benefits as a suitable cooker in the jelly and gelatin confectionery markets as well as other food markets.