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Aseptic Canning of Dairy Products

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'Aseptic canning' is the term used here to describe the canning system whereby the food product is sterilised prior to filling in contrast to post-packaging sterilisation where the product is heat-sterilised after hermetic sealing. The purpose of this article is to survey the present status of the aseptic canning of dairy products in the U.S.A.

ASEPTIC canning is not a new idea: the general requirements for an aseptic canning system have been known for several decades. The *HCF*, *Avoset* and the *Martin* (now known as the *Dole* system) are aseptic canning ideas that have been developed and used in at least one commercial installation. The *HCF* and *Avoset* systems are fully described by Ball and Olson,[1] and additional material on the *Dole* system is provided by Martin.[2,3] Only the *Dole* system has been used extensively, there being about 44 installations to date.

The advantage of aseptic canning over the conventional system of sterilisation in the container is improved product quality. Aseptically canned foods are of higher quality because they are subjected to a less severe heat treatment as far as colour, flavour and heat labile nutrients are concerned even though the heat treatment is usually equal to or more severe, bacteriologically, than that of the conventional system. This is possible because the temperature coefficient of bacterial destruction is about five times the temperature coefficient for the destruction of colour, flavour and heat labile nutrients. Milk is one of the many foods that is heat sensitive in respect of flavour, and although it cannot be canned in present systems using in-container sterilisation without developing an undesirable cooked flavour, it can be sterilised by the high-temperature short-time (H.T.S.T.) process and aseptically canned without acquiring this flavour.

The improved quality of aseptically canned food products is achieved by taking advantage of the difference in thermal destruction rates between bacteria and quality factors, such as thiamine destruction, illustrated in Fig. 1 and discussed below. Therefore, the advantage of the method lies not in the fact that aseptic canning *per se* is superior, but that H.T.S.T. sterilisation is more efficient than low-temperature, in-container sterilisation. The aseptic canning system is simply the vehicle which makes possible the use of H.T.S.T. treatment.

The following example from the vegetable canning industry is presented to give a better understanding of the phenomenon that makes possible a reduction in heat damage without reducing the bactericidal effect. A thermal destruction curve with an $F_o = 6.0$ min. (F_o is the

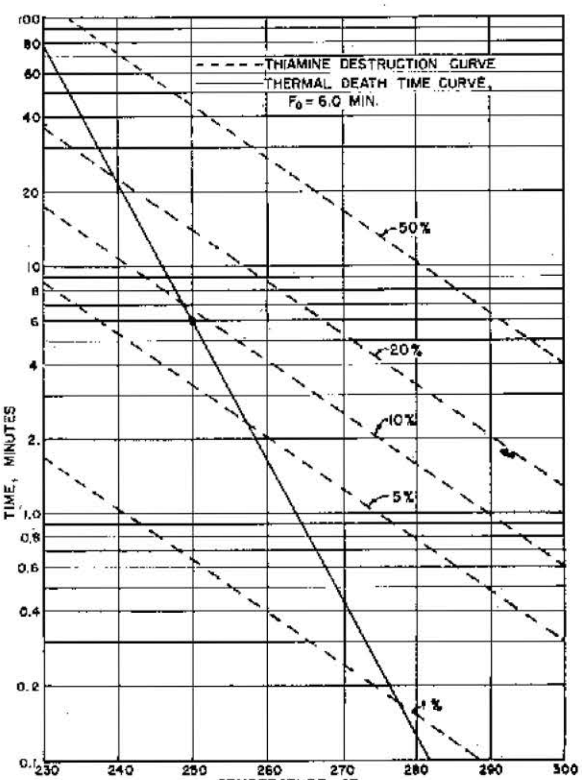

Fig. 1. The time-temperature sterilisation curve for bacteria and for 1, 5, 10, 20 *and* 50% *destruction of thiamine.*

equivalent of a thermal process in minutes at 250°F.; the suffix indicates that the thermal death time curve has a slope (z) of 18°F.) and time-temperature curves to destroy 1.0, 5.0, 10.0, 20.0 and 50.0% of the thiamine present in strained vegetables (data from Feliciotti and Esselen[4]) are shown in Fig. 1. This figure illustrates the difference between the destruction characteristics of bacteria and of quality factors; with an equivalent bactericidal process, less than 1% of the thiamine is destroyed at 280°F., compared with over 20% at 240°F. It may be possible to sterilise concentrated or evaporated milk in the new type of continuous agitating retorts or autoclaves at temperatures of 260 to 265°F. with very low quality loss. At 265°F., for example, an equivalent bactericidal process will destroy less than 3% of the thiamine. Therefore, the development of new high temperature, post-packaging sterilisation equipment may eliminate some of the present advantages of aseptic canning.

The thermal processes used to sterilise whole milk are variable but are in the range of an F_o = 10-12 min., disregarding the lethal effect accumulated during heating and cooling. Typical processes are: heat to 285°F., hold for 0.13 min. (8 sec.) cool; and heat to 300°F., then flash cool to 212°F.; although no hold is measured, it is probably at least 0.017 min. (1 sec.).

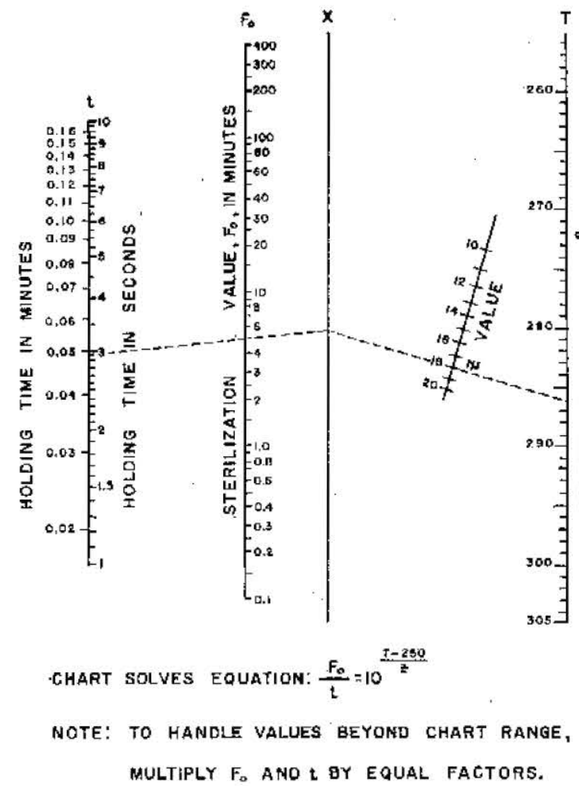

Fig. 2. This alignment chart for computing H.T.S.T. processes was designed by J. F. Ryan, James Dole Engineering Co.

The alignment chart in Fig. 2 can be conveniently used to calculate the lethal value of H.T.S.T. sterilisation processes.

Aseptic canning in practice

The basic requirement in operating an aseptic canning system is that the product be heated quickly to a sterilisation temperature, held until sterile, then aseptically cooled, aseptically filled into sterile containers and the containers aseptically sealed. Essentially, one surviving organism per container is all that is necessary for a total loss.

The equipment now being used in commercial aseptic canning systems in the U.S.A. is as follows:—

Heating and cooling product:

1. Tubular or modified tubular type heat exchanger.
2. Scraped surface heat exchanger.
3. Direct steam heating plus evaporative cooling.

Can and cover sterilisation and can filling:

Dole system using steam for sterilisation of cans and covers and for maintaining a sterile atmosphere during filling and closing.

Sealing cans:

1. Single head seamers.
2. Multiple head seamers.

A plant arrangement for an aseptic canning system is shown diagrammatically in Fig. 4 and Fig. 5 shows the can and cover steriliser, filler, closing machine and control panel.

Heat treatment

Three types of heat exchanger are used to transfer heat to the product prior to sterilisation and remove this heat after sterilisation. These are the tubular or modified tubular, scraped surface and direct steam injection heaters. In general, the equipment available for heating dairy products to 280 or 300°F. for sterilisation and aseptic canning is identical to that being used for ultra high temperature (U.H.T.) pasteurisation. This equipment is described by both Capstick[5] and Hall and Trout.[6]

Can and cover sterilisation, filling and sealing

At the present time, the *Dole* system is the only commercially available aseptic canning unit. The can and cover steriliser, filler and modified sealing machine are supplied together as the *Dole* system. Superheated steam is used to sterilise the cans and covers and the filler and closing machine before start-up and to maintain a sterile atmosphere in the filler and closing machine during operation. As a bactericidal agent, superheated steam is not nearly so efficient as saturated steam but, if the temperature is high enough, it will adequately sterilise a clean dry surface. The advantage of superheated steam is that it is at atmospheric pressure, thereby eliminating the need to valve the containers into and out of the sterilising chamber. As a result, the can and cover sterilising apparatus are simple compared with a system which uses saturated steam under pressure. The low heat transfer rate, *i.e.* low condensation rate, of superheated steam makes it an ideal medium to maintain sterile conditions in the filler and closing machine without contaminating a cold food product.

The empty cans are sterilised by passing through a tunnel where superheated steam is directed against the bottom of the can from below and to its interior from above. The cans are carried on a cable conveyor, one against the other, and the time taken to pass through the steriliser varies between 40 sec. and 1 min. The superheated steam temperature is often as high as 525-550°F. and the duct temperature may be as high as 490°F. The temperature of the cans is in the range of 420 to 425°F., and that of the covers, 410 to 415°F. Since tin starts to melt at 450°F., care must be exercised to ensure that the container is not damaged due to excessive temperatures.

The cover steriliser consists of a box enclosing two screws which separate the covers and feed them to the cover feed of the closing machine. Superheated steam is blown between the covers as they pass down these screws to raise the temperature to a point adequate to produce a sterile surface. The cover sterilising time is usually a little over 1 min., but may reach 1·5 min. Consequently, the temperature of the cover does not have to be quite so high as that necessary to achieve a sterile can.

The filler used in the *Dole* system is usually of the slot type. Filling is governed by the length of the slot, the relative rate of liquid flow from the filling nozzle and the speed of the can conveyor system, *i.e.* the length of time the cans are under the filling nozzle. The cans are advanced under the filling nozzle by a screw conveyor with a variable speed drive that readily allows the operator to adjust the filling rate. Before filling, the empty cans are cooled slightly by sprays of cold, sterile water. The flanges are overlapped to minimize loss of product as the cans pass under the filling nozzle. After filling, the cans are separated by the screw and timed into the seaming machine. As the can passes into the seamer, it receives a sterile cover which is double seamed to the can. The filled can is then discharged and is usually ready for packing, although in a few instances further cooling is necessary.

The atmosphere in the filling and sealing chambers is usually composed of superheated-steam, but flue gas from the superheater burners is used in some units to dilute the superheated-steam and thereby reduce the vacuum in the cans. An extremely high vacuum is produced if all the gas in the headspace at the time of sealing is steam. Standard types of single and multiple seaming-head closing machines are modified and used in the *Dole* system.

The temperature measuring, control and alarm system is a very important part of the aseptic canning unit. Both the product sterilisa-

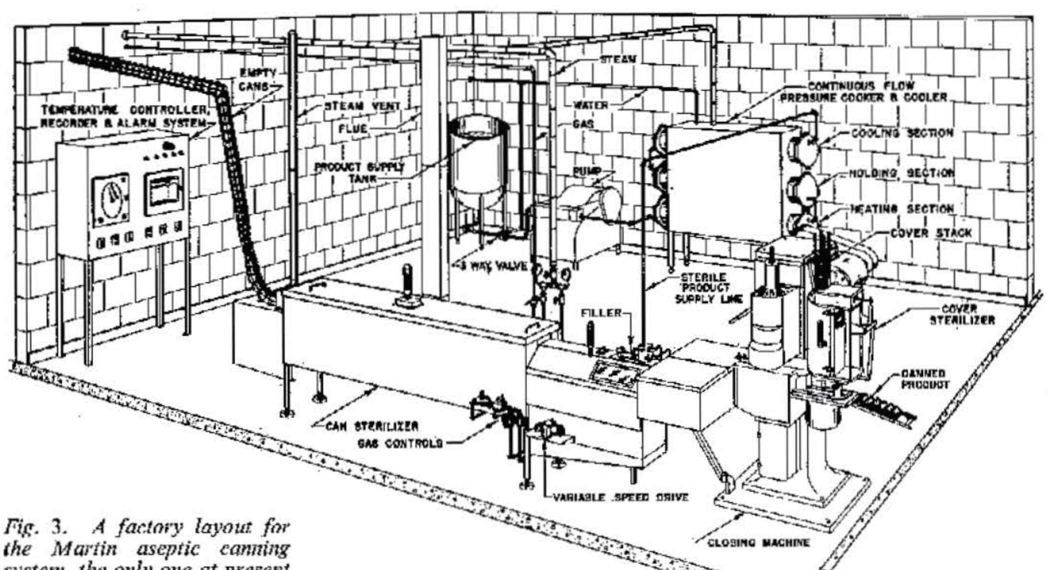

Fig. 3. A factory layout for the Martin aseptic canning system, the only one at present commercially available in the U.S.A.

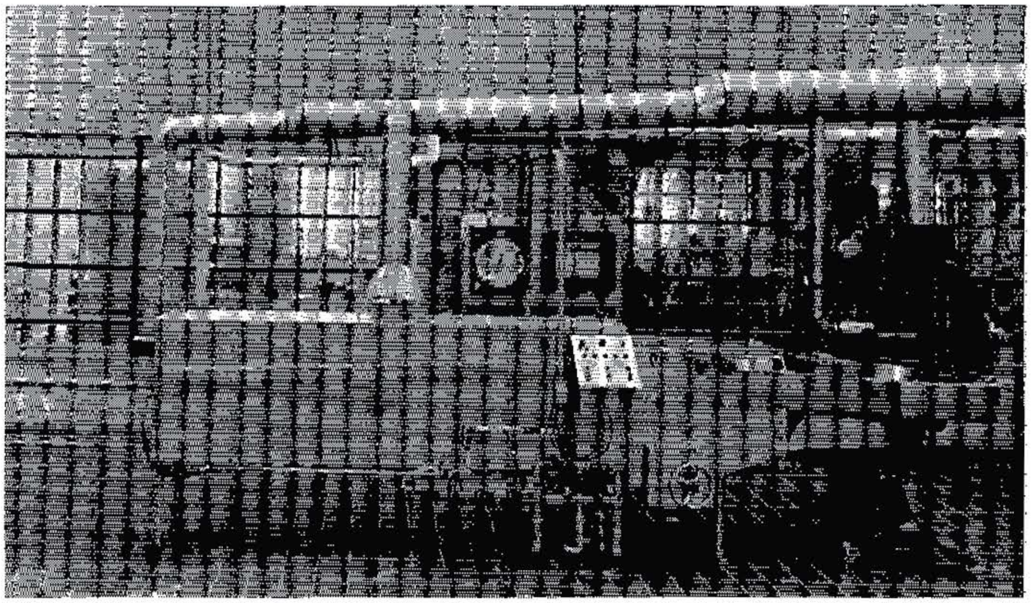

Fig. 4. The Dole can and cover steriliser, filler, closing machine and control panel.

tion system and the can and cover sterilisation system are equipped with automatic controls to maintain a constant temperature. In addition, all critical temperatures are monitored in a system that both records the temperature and sounds an alarm if the temperature at a critical point drops below the safety level.

Applications in the dairy industry

Aseptic canning is used primarily for special dairy products, the products most widely canned in this way being whole milks for use in non-milk producing areas, chiefly for the Armed Forces, concentrated milks, milk drinks such as chocolate milk, coffee and whipping cream, ice cream mixes and formulated infant foods. There are approximately 10 plants in the U.S.A. equipped for aseptic canning of pre-sterilised dairy products. The bulk of the canning is done with the No. 10 (603 x 700) size, which on the average contains 3.0 qt. of liquid product. Only a few specialised products are packed in small containers for direct sale to the consumer, but it is expected that more aseptically canned foods will be on the market in the future.

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