Paper No.: 02

Paper Title: The Principles of the Food Processing & Preservation

Module No. : 10

Module Title: Retort Processing of Food

10.0 Introduction

Shelf life of a food is integrally related to its packaging and the product conditions. The major driving forces for innovation in food packaging technology had increased due to the rise in consumer demands. Retort technology systems use steam or superheated water to cook food in its own package, thus extending shelf life and ensuring food safety. Manufacturers of food products who face a challenge in making their packaging product attractive to consumers should design packages with an innovative look. The revolution in packaging technology has boost up food suppliers mind to be creative in providing a convenient food to the consumer. In fact most of the grocery shops or supermarkets want the food product they buy from the manufacturer to be as convenient as possible. In fact, from the consumer point of view, the less time they spend to prepare a meal, the better. As mentioned before, new advance in technology of packaging has begun to transform the marketing and goods of food products. Retort pouch technology is the solution to meet consumers demand that will help consumers save time and energy.

Autoclaves, known as retorts in the food industry, have been a major technological feature of preserved foods for over 100 years. Indeed, the first documented use of heat to preserve foods in a commercial application dates back to the Napoleonic Wars of the early 1800s and has been a reliable and straight forward methodology ever since. By the time of Waterloo, British troops had canned rations and these also assisted many of the 19th and early 20th century explorers to reach their destinations. It was a confectioner, Nicholas Appert in 1804, who sealed glass jars with pitch and discovered a way of keeping food such as mutton, vegetables and milk from spoiling. Then in 1810, Pierre Durand, was granted an English patent for the metal can, which, with a few minor differences, is still the most common container for preserved foods today. But it was not until Louis Pasteur in 1854 demonstrated the effect of micro-organism spoilage on milk that we understood why heat is such an effective and safe form of preservation.

Over the years, we have seen the introduction of a new generation of materials such as pouches, plastic pots and trays, allowing more convenience, better product quality through reduced processing time, reduction in costs for food manufacturers and better surfaces on which to provide the increasing depth of information that consumers and marketers demand. Apart from retorts, which are batch operations where the product is introduced in a crate or basket, there are continuous systems such as hydrostatic, continuous rotary and Hydroloc systems, but these are universally used for metal cans and have not been widely used successfully for novel applications.

10.1 Retort process types

There are three basic retort processes: steam, falling water and full water immersion. There are also sub-divisions within each of these categories including steam/ air, steam-spray, water spray and half immersion. It should be emphasised that all the processes, bar simple steam, will work on all of the current container formats, so there is not necessarily a ówrongô process for novel applications. However, it is clear that some principles of transferring heat to sealed containers do have advantages over others when specifying particular packaging media. This is particularly so when choosing between rigid, semi-rigid and flexible formats. Whilst the tin can is processed in all three heating mediums, plastic pouches and CPET (crystalline polyethylene terephthalate) trays used for ready-meal production have different requirements.

10.2 The steam process

10.2.1 Steam: This is the oldest form of autoclave and is usually a top-loaded, vertical pressure vessel with straight forward controls. Pressurised steam is admitted to the chamber, driving the air atmosphere out of the top of the vessel in a óventô phase lasting up to ten minutes. This valve is then closed and the temperature raised by injecting steam, creating overpressure from the temperature increase. Thus there is no independent control of temperature and pressure and because the gaseous medium is not mixed or agitated, air must be eliminated during the vent phase to ensure there are no ócold spotsôï pockets where the temperature is significantly lower due to stratification ï since air and steam do not readily mix without assistance. Cooling is achieved by flooding the chamber.

The technology used in this type of retort presents significant challenges for modern processors. The vent procedure is expensive because up to 36% of the steam required for the process is simply exhausted to atmosphere; the pressure fluctuations mean that it is virtually impossible to process pouches, semi-rigid pots and trays without distortion of the packs or the risk of cold spots occurring if compressed air is used to artificially create overpressure; and the vertical orientation of the retort means that full automation of basket loading is not achievable.

10.2.2 Steam/air: The steam/air process is a highly effective development of the steam process. Major differences from the steam retort are horizontal vessels with quick opening doors to facilitate basket loading and unloading, forced steam circulation and most importantly, independent control of temperature and pressure. The steam/air process was patented by Lagarde Autoclaves in 1972. The steam is injected directly into the vessel and a reduced venting time is achieved by the use of a high velocity fan to re-circulate and mix the steam with any residual air, eliminating the occurrence of cold spots. This highly efficient process was specifically developed for flexible and semi-rigid containers, initially for military rations in aluminium foil packs, but has seen many applications on stand-up pouches and ready meals. It offers rapid heating to give the shortest process times to maximise food quality. Cooling consists of two steps ï a pre-cooling step that first cools the retort chamber, gradually replacing the pressurised steam environment with compressed air, and a second step that showers the hot containers with cold water, which is re-circulated through an energy recovering heat exchanger (Figure.1). With the latest technology in automation, using robots, the production from these types of retorts is highly efficient, with short cycle times.

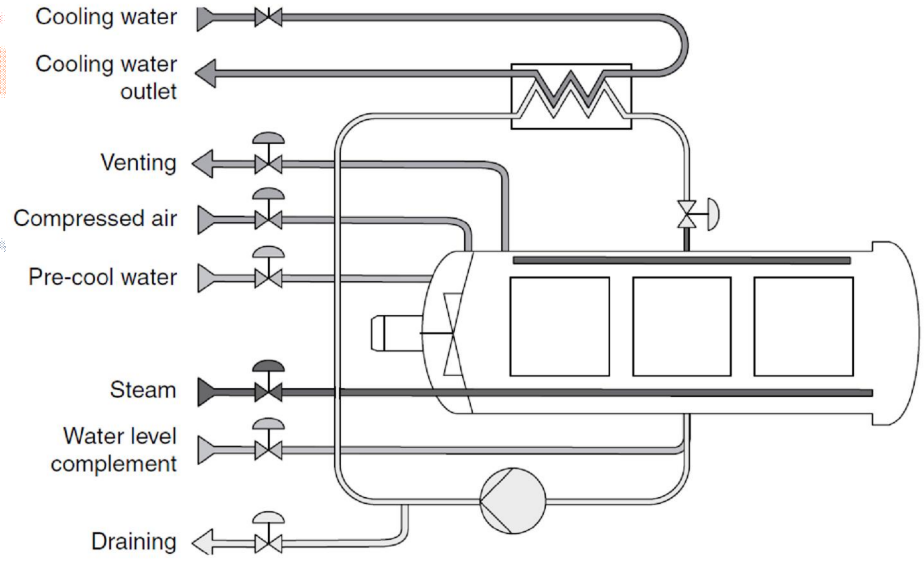

Figure 1: Steam and air

10.3 The water process

10.3.1 Steam/spray: This is a relative newcomer to batch retorting processes. In 1983, Surdry of Spain patented a process that combined steam and water in an atomised spray. The atomised

environment gives a very good heat transfer on rigid containers during the come-up or heating phase, as the water transfers its heat very quickly. A fan is not utilised to mix the atmosphere. Atomising nozzles placed around the circumference of the retort take water from a pump, re-circulating the condensate, and mix it with steam directly injected into the chamber. Whilst rapid heating can be achieved, the atomising nozzles, by their design, tend to restrict the water during cooling, leading to longer processing times than conventional cascading water, immersion or water spray types (Fig.2). To get round this restriction, other manufacturers of this type of retort, have considered and implemented separate heating and cooling circuits to maximise the efficiency of the process.

Figure 2: Water spray retort

10.3.2 Raining or cascading water: The raining or cascading water system uses superheated water, under overpressure to achieve sterilisation temperatures. Water is heated through a heat exchanger and then pumped through a distribution plate, and showers under low pressure onto the containers below (Fig. 3). This methodology is widely used in the processing of glass containers as the water can pass between the containers as it falls, transferring heat through the side walls of the container. The cascading water process was first introduced by Barriquand of France in 1975. The exchanger in the circuit allows steam that is used to heat the process water to be recovered as condensate, and it can then be returned to the boiler for re-heating. Care should be taken in the re-use of condensate because of the concentration of minerals and the resulting acidification of the steam.

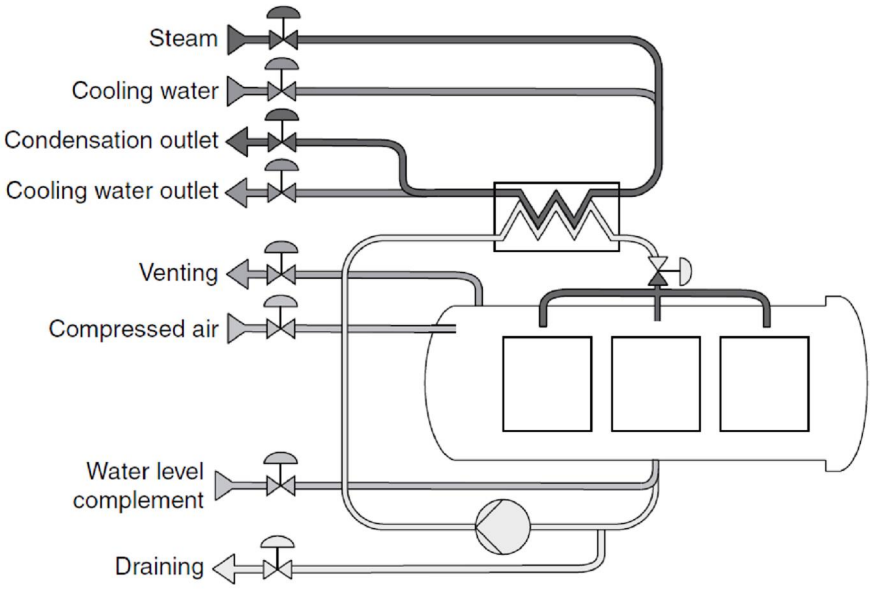

Figure 3: Hot water

10.3.3 Full water immersion: Another technology in widespread use is the full water immersion retort. This is comprised of a processing vessel and a pressurised water reservoir (Fig. 4). At the start of the process, hot water from the reservoir floods the lower chamber and is then re-heated to sterilisation temperatures. After the cooking process, the water is returned to the reservoir, ready for the next process. A small amount of water is retained in the processing vessel and is then re-circulated and cooled through an exchanger, to be sprayed onto the products for cooling. The use of pouches and trays have tended to work against this process as the flotation of packs needs to be controlled, leading to increased costs in basket manufacture and reduced flexibility.

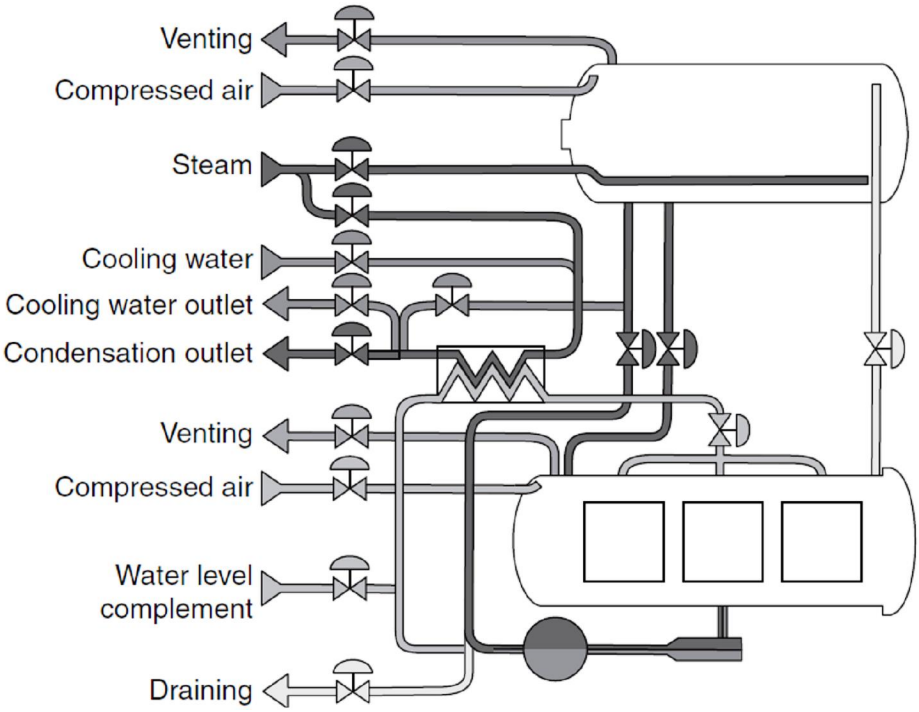

Figure 4: Full water immersion

10.3.4 Half water immersion: Half immersion is where the vessel is half filled with water and part of the rotation is in water and part out of the water. This can give advantages when rotation speeds are high, as there is less turbulence created by the cage.

10.4 The best retort process

It is impossible to select a single process and conclude that it is the optimal solution for every container type. However, there are distinct advantages and disadvantages when selecting a process type. The steam/air process has been widely utilised in processing semi-rigid and pouch containers and is currently the most popular method for processing pouches, especially in the pet food sector where the highest volume of stand-up pouches is manufactured. As steam is a three-dimensional heating medium, there is virtually no difference in pouch come-up times, whatever the position of the pouch in the basket. Rapid cycle times can be achieved, as the application of energy is direct to the pack, the amount of free energy available is greater in a steam environment than in a water based process, and there is no loss of energy through indirect heat exchangers. This leads to significant utility savings and increased output compared with a similar sized vessel using an alternative heating method. It must be emphasized that the recirculation fan is critical to the effectiveness of the process and various safeguards to ensure fan operation are usually incorporated by the retort manufacture for both rotation and load. In addition, many novel containers have plastic laminates with gas barriers that are sensitive to water at high temperatures, so a steam process is less invasive at temperature than either cascading water or full water immersion, as the rate of condensation at the hottest part of the cycle is low.

The steam/spray process gives good distribution during come-up, but the pressure on each nozzle is critical to obtaining the correct atomisation. In addition, there are concerns with flat containers about the so-called úmbrella effectô where, during come-up and hold, flat packs such as trays and pouches are shielded from the atomised environment due to the packs above them inhibiting the flow. Even with side sprays, good penetration cannot always be guaranteed where the layers of trays or pouches are tightly packed. Additionally, maintenance of the nozzles to ensure they remain free of scale or other particulates is critical. This is somewhat difficult without entering the retort and removing the nozzles, as it is impossible to see which nozzles are blocked from the mouth of the vessel. Falling or cascading water is highly effective at penetrating tightly packed baskets of rigid containers, such as glass or cans, as the vertical medium of water can penetrate between the containers, trickling down from top to bottom. Good thermal distribution is achieved by high flow, but the reservations are similar to those with the steam/spray process when pouches or flat pots and trays are processed. Here, the umbrella effect has to be again considered. Many of the problems with the umbrella effect can be overcome with the use of rotating retorts, where, due to the containers turning end-over-end, water can penetrate more easily. By design, the water spray process means that products take longer to heat then in a steam retort, as the water has to be heated prior to being sprayed on the containers or heated during spraying if the product is cold filled, and the heat loss throughout the exchanger should be taken into account when calculating steam requirements.

The immersion process is a very good one for delicate heating for many products and containers. In heavy loads, the water immersion route does give additional support to the weight of the containers, but this is often countered by the slower process times inherent when heating such a large body of water. In addition, with the poorer nature of the seal qualities on semi-rigid and pouched containers, with contaminated water being transferred from batch to batch from óleakersô, there is an issue with colouring of white plastics, sticky residues on packs, as well as water migration through seals, that makes the application of full water immersion processes for low temperature pasteurization more complicated.

10.5 New packaging developments

With the use of thinner gauge glass and metal containers to reduce cost and with the adoption of so many plastics containers, retorts have had to change rapidly to accommodate the more accurate and shorter processes required. The level of control directly affects the failure rate of semi-rigid or flexible containers. Better temperature and overpressure control places less stress on the materials, ensuring the seals remain hermetic and reducing the level of wastage. This is particularly true of CPET trays, where fluctuations either lead to blown seals or deformed containers, which are then rejected by retailers.

The wider use of recyclable plastics in food, dairy and beverage applications also requires accurate processing, and screen-printed containers have been better served by steam rather than by water-based processing. The stand-up or Doy-pack plastic pouch has emerged as one of the major alternative formats to glass and metal rigid containers. The most successful products have been pet food and carbohydrates, such as rice and pasta. Indeed, recent data show the phenomenal growth in sales of pre-cooked rice in pouches growing at an annualised rate in excess of 25% per year. Stand-up pouches require careful processing as poor pressure control can lead to the failure of the gusset due to mechanical strain. As the heat penetration time to the core is so short, the process medium chosen needs to reflect this and be able to supply large amounts of energy during the heating stage very rapidly, with minimal thermal lag between top and bottom of the basket. A difference in internal temperatures of each pack will lead to varying amounts of overpressure requirement, which is impossible to resolve in one common environment. The accurate control of retort pressure is therefore crucial to success.

Other new containers such as Tetra Recart also require specific thermal processing solutions to avoid damage. A paper-based container in a wet, hot environment is not usually a good combination. However, the laminate make-up does allow full sterilisation, though care has to be taken not to damage packs and to avoid too much water at high temperature in contact with the inks behind the surface lacquer. Damage to the surface during filling can result in inks running during the process. Most of the retort manufacturers have recognised that retort control is crucial for new-style containers and much effort is being made to use the latest electronic hardware to ensure accuracy. The ability to reduce process times to the optimum is a driver for food and consequently for autoclave manufacturers.

10.6 Advances in retort technology

Retort manufacturers try to evolve their equipment continuously, so the retort available today is significantly different from the machines available 10ï 15 years ago. The fact that the design life of a retort is often 25ï 30 years also steers development. Below is a list of some of the latest retort developments.

10.6.1 Dual process: Most retort manufacturers are happy to argue that their process design, whether steam or water-based, is the optimum process for any type of container or product, but this can be quite easily disproved. We know in general terms that steam/air is good for plastics and pouch, water for rigid containers, such as cans and glass. But surely the optimum is a mixture of the two. Water immersion retort manufacturers have offered the ability to shower or immerse products for a number of years, but recently Lagarde Autoclaves have pioneered the development and installation of dual process retorts that can use either steam or water processes at the touch of a button. The first installations have been to traditional food canners (Fig. 5) with an eye to divert some of their products into more convenient or modern pack formats, such as pouch or polypropylene based bowls. The dual process facility allows optimum processing times on rigid containers using water spray, and rapid heating to achieve short processing times for pouches. This gives the food manufacturer the ultimate retorting facility, capable of flexible, efficient manufacturing of any container shape or type.

Figure. 5: Dual process retorts

10.6.2 Sterile cooling: Often fresh water is introduced to top up process water. An internal pre-heating system can now be fitted to pre-sterilise fresh water to ensure sterility in the case of sensitive packaging materials or double safety on pharmaceutical or infant food products. These exchangers can also be used as indirect cooling systems for applications where water is not desired to be in contact with the container. Some vented food packs are especially sensitive, as the vent is open during cooking but needs to be closed by a fall in temperature, to ensure a hermetic seal. In traditional water cooling there would be a risk of water passing through the vent before it is fully closed, with the consequence of contaminated packs.

10.6.3 Rotational speed (rotary retorts): With the requirement of shorter process times for better quality, the average speed of basket rotation is increasing. Some products are now being rotated at speeds in excess of 15rpm to obtain even re-hydration or effective starch breakdown used in sauce and soup preparation. These speeds tend to prohibit the use of water-based processes as they are subject to both centrifugal force in the case of falling water or cavitation and poor flow dynamics in the case of full water immersion, where the rotating cage acts a giant paddle. In both cases, even distribution requires the replacement of heat absorbed during the heating stage. If the water is unable to penetrate effectively to the centre of the basket, the result is poorer distribution.

10.6.4 Basket sizes: With pouch products, the weight of product in each basket has fallen, but because of the need to contain pouches within individual pockets to avoid damage in rotary retorts, the overall basket weight has risen. This has placed additional stresses on mechanical components within rotary retorts. Retort manufacturers have a fairly common design for the drive system of the internal cage inside rotary retorts (Fig.6). The cage shaft is powered by a rear-mounted external drive through a mechanical seal. The front of the cage is mounted on two rollers or trunnions. Traditionally, these have been mounted inside the pressure vessel. A number of manufacturers have now mounted these ówearingô parts externally in separate pressure housings, allowing easier maintenance. The heaviest loading, however, is for processing glass jars. Line speeds continue to increase and this requires bigger basket capacities. Trunnions can now be powered by linked drives so that there is less torsion on the retort cage and less stress on the shell than with free-wheeling trunnions. Pouch basket capacities continue to grow as food manufacturers try to gain greater efficiencies from each process. The latest retorts are now capable of processing around 3600 × 400 grams of pouches per batch.

Figure 6: Rotary retort cage

10.7 Future trends

Over the last 10 years, there has been a significant change in the profile of retort users. Previously an exclusive ambient foods club, retort ownership has diversified to such an extent that many of todayôs major installations are on chilled pasteurized products, such as ready meals, soups and vegetables, or in component processing for use in the production of other foods, such as rice and protein cooking prior to inclusion in recipe dishes. Additionally, the food service sector has been looking at methods of extending life and making the distribution chain more efficient.

Traditionally, products being delivered into the restaurant or ópubô markets needed to be ambient or frozen, but the increasing use of microwave ovens for food preparation has increased the usage of chilled prepared meals. Hospitals and schools are also searching for more healthy foods, but with further cost savings. The reduction of salt is a major factor in this area. Fourteen days of shelf-life at retail outlets with no discernable reduction in quality or flavour is a major advancement. Indeed, many products benefit from a double cook or in-pack cooking, leading to a more rounded flavour. Cheaper cuts of meat, such as shin beef or brisket, can be tenderised within the retort at low temperatures, and cooling systems mean the product can be discharged at chill temperatures across a high risk/low risk separation regime without additional handling. Because there is no down time for cleaning between processes, a retort is very flexible when it comes to handling the wide range of products found in chilled food manufacture.

The increasing use of organic and spice ingredients, some with high initial microbial counts, have led to the need to decontaminate by using pasteurisation or sterilisation, and many food ingredient manufacturers now use retorts for products such as marinades and sauces in 5 and 10 kg pouches. Hot filling at 85 °C on these types of products is not necessarily enough to eliminate yeasts, moulds and other spoilage organisms. Many governments, due to increasing domestic health problems with obesity and cardio-vascular disease, are championing salt reduction in processed foods. Chilled products are now under intense scrutiny by officialdom and the media. Thermal processing requires no other preservatives and óretort cookedô low-salt ready meals can now achieve long shelf-life without additional ingredients. In this way the additional cost of the thermal process can be obviated by a reduction in the cost of preservative and stabilising ingredients.

Another recent application has been the pre-cooking of ham shanks and belly pork joints. The product, once cooked and cooled in a bag, is then dispatched to stores with hot food counters, then finished off in roasting cabinets. The process not only reduces cooking time, but also ensures product safety and good quality without variability. Seafood processors are able to use retorts for

gentle controlled defrosting; the product is then prepared and finally cooked or pasteurised in the retort prior to despatch. The two largest chilled seafood producers in Europe are now using retort technology to process fish ready meals, taking shelf-life from a market-limiting 4 days to an acceptable 17 days, whilst still ensuring that the quality is the same or better compared with chilled assembly.

With the continuing consumer drive towards more convenience, vegetable growers are now reaping additional margin by processing vegetables to a ready-to-eat state in pouch and tray. Chipped, boiled, mashed and even jacket potatoes, part cooked, are flooding the chilled foods market and they require only reheating in a microwave. As well as potatoes, other root and green vegetables are processed to offer maximum convenience. With steam/air retorts it is also possible to steam ónunpackedô product, loose in stainless retort trays, such as cauliflower, broccoli, mange-tout and leaf products including spinach. The aim is not to increase shelf-life, but to give minimal cook and then use cryogenic gas cooling to maintain colour without damaging the structure of the delicate product. Whilst more expensive than traditional cooking methods, structure, colour and nutrient loss are minimal.

10.8 Conclusions

Retort processing of foods in rigid, semi-rigid and flexible packaging systems is the most acceptable form of food preservation. It represents unique combination of package, process and product technology with potential, economic benefits. Traditionally, tin containers have contributed to a large extent in building the confidence in processed foods. The increasing public awareness and aversion to accept other methods of food preservation like chemical preservation, irradiation, etc. have offered a vast scope for retort processing of foods. The emerging technology in the food packaging industry resulted from the increasing demand among consumers. Convenience is the major driver in the food industry today. As this is unlikely to change, more and more delicate packs will emerge, to tempt consumers to associate thermally preserved foods with fresh chilled alternatives.