# Thermal, non-thermal processing

Thermal processing is still the major technique for shelf-stable food preservation, but other technologies are finding applications.

Dan Farkas (phone 415-332-5461), Professor Emeritus of Food Science at Oregon State University—and the most recent winner of the Institute of Food Technologists' Nicholas Appert Award, which is named for the founder of thermal processing— observed that there is a general movement in food processing away from high heat treatment and deep-freezing toward milder treatments, resulting in refrigerated foods with less cooked flavors.

Here is a discussion of some of the nonthermal techniques being investigated, and in some instances commercially applied, along with a discussion of developments in thermal processing.

## Nonthermal Processes

There always is the need to kill pathogens, but there is also a demand for "clean" labels, meaning a preference for few, if any, chemical additives and preservatives.

Traditional thermal processing was focused on killing spores of *Clostridium botulinum* in low-acid foods. Refrigerated foods, which often receive little heat treatment, can be contaminated with less-heat-resistant species such as *Listeria, Salmonella,* and *Escherichia coli.* Nonthermal techniques, such as irradiation and high hydrostatic pressure, can destroy these organisms with little damage to the food.

• **High Hydrostatic Pressure.** Farkas pointed out that high pressure, with which he has current experience through Elmhurst Research, Albany, N.Y., does not inactivate enzymes, which can cause various negative effects, such as discoloration,bitter flavors, and softening. Some mild heating is required to inactivate enzymes.

A specific example he cited was preparation of a fruit mixture, such as might be used in fruit salad. The pH was lowered by using deflavored lemon juice, though other acids could also be used. The mixture is heated at 70°C for about 10 min, then subjected to 85,000 psi. The result is almost fresh tasting.

Elmhurst Research, which competes with Avure, Kent, Wash., winner of IFT's 2002 Food Technology Industrial Achievement Award, builds its high-pressure units from surplus cannon barrels. Its first commercial installation, according to Farkas, is a reliability demonstration,which should result in some sales. The goal is to demonstrate 15 cycles/hr for 20 hr over multiple days. The cycling will stress valves, piping, and instruments, as well as the pressure vessels.

Current commercial products processed with high pressure include guacamole and fruit juices. Probably for economic reasons, the meat industry has not embraced high pressure.

Sudhir Sastry, Professor of Food Science at The Ohio State University (phone 614-292-3508), is also studying high pressure. He described a variation he called pressure-assisted thermal treatment, in which food is heated to about 90°C, then pressurized to about 100,000 psi. The adiabatic heating raises the temperature to about 121°C, hot enough to kill *C. botulinum*. This permits treatment of low-acid foods, and the heating inactivates enzymes. The advantage of the process is that when pressure is released, cooling is very quick. In conventional thermal processing, cooling can be slow, and much of the damage to flavor and texture occurs then.

Ohio State is obtaining another researcher with experience in high pressure and related technologies, V.M. (Bala) Balasubramanian, formerly at the National Center for Food Safety and Technology, part of the Illinois Institute of Technology. Bala was one of the first to observe the importance of adiabatic heating during high-pressure processing.

• **Irradiation.** Irradiation has been approved for use on meats and some other foods. Since the Food and Drug Administration considers it a food additive, it cannot be used on foods labeled "organic."

There are two approaches to irradiation: use of radioactive isotopes, such as cesium or cobalt, and electrically generated radiation, such as X-rays or electron beams. Isotopes produce penetrating gamma rays and require expensive facilities with heavy shielding, because the radiation is always on and could pose a hazard to workers. Electrically generated radiation has less penetration strength and so is only useful for surface sterilization or on thin products. However, it is safer and less expensive to use, because it is turned on and off as needed and does not require shielding.

Commercial equipment for both approaches is available. IBA Food Safety Div., Memphis, Tenn., offers cobalt-based irradiation services and facilities. SureBeam Corp., San Diego, Calif., offers electron-beam equipment and recently installed a unit at Texas A&M University for research.

Farkas pointed out that irradiation also requires some thermal assistance in many foods because it does not inactivate enzymes. At very high doses (50,000 Gray), off flavors develop in irradiated meats. Mild heating can reduce this issue.

An especially promising application of irradiation is to treat grain bound for export, in place of methyl bromide, which is being phased out. Grain can be pneumatically conveyed through an exposure zone very quickly and all pests killed. In this case, insects and their eggs are the target.

• **Pulsed Electric Fields.** Sastry is also conducting research on pulsed electric field (PEF) preservation of foods. He and his Ohio State colleagues Howard Zhang and Peter Yin hold a patent on the concept, which is assigned to the university. A high-frequency field is used to destroy harmful microorganisms in microseconds of exposure. The time is so short that there is no heating. It is thought that the microbes are destroyed by perforation of cell walls. The same phenomenon also affects juice pulp cells, reducing the suspended particle size in orange and tomato juices treated with PEF. This has the benefit of reducing sedimentation or settling of solids in juice. PEF is considered a form of pasteurization, suitable for high-acid foods, such as fruit juices.

• **Other Nonthermal Processes.** Sastry mentioned that ohmic heating, in which electrical resistance is the source of heating, had been in decline after a flurry of interest but was showing some signs of commercial interest. Several units have recently been installed, though he could not provide more details because of proprietary restrictions.

Researchers at Ohio State have also investigated the effect of carbon dioxide on high-pressure treatment. It is known that carbon dioxide has some antimicrobial properties. It dissolves at high pressures and comes back out of solution when the pressure is released. This appears to enhance the destructive effect on spoilage organisms in juice.

Another center of research on nonthermal processes is Washington State University, Pullman. Gustavo Barbosa-Cánovas (phone 509-335-6188), Professor of Food Engineering in the Dept. of Biological Systems Engineering, and his colleagues have written extensively on high pressure and other processes.

### Developments in Thermal Processing

While traditional thermal processing is usually associated with metal cans and glass jars, the newest developments involve new packaging materials and forms. One example is the flexible retortable pouch, originally developed for military rations and commercialized in the late 1970s by Continental Baking and Kraft Foods. Except for military use, the retort pouch has languished until recently, when it has been applied to tuna and pet foods.

The pouch was touted as a low-profile, inexpensive package, but it suffered from a requirement for 100% inspection of seals and relatively low-speed filling lines. Newer pouches have gussets to enable them to stand up, and some have zippers to allow reclosing. The standup pouch can eliminate the need for a carton, saving costs and providing an opportunity for use of striking graphics on the pouch.

The original pouch structure involved a heat-sealable polyolefin inner layer (polyethylene or polypropylene), adhesive, aluminum foil, adhesive, and a polyester outer film. The aluminum provided physical strength and a barrier to oxygen and moisture. Newer pouches add a nylon layer for additional strength, especially in larger pouches and for the military, which still relies on foods in pouches for its Meal Ready-to-Eat (MRE).

Many of the products introduced in pouches are co-manufactured by firms whose major customer is the Pentagon. The feast-or-famine nature of military procurement cycles has made that business a difficult challenge. Civilian applications help absorb capacity that is required for defense and relief emergencies.

Another older technology that has proven durable and seems to be getting more attention is rotary retorting. Applied originally to large metal cans, such as No. 10 sizes for foodservice, rotation helps agitate the contents of a container during heating and cooling, thus shortening the processing time and reducing damage to flavor and texture. Rotary retorts are manufactured by several firms, but one that has built an integrated strategy around them is Stock America, Grafton, Wis.

Mike Galvin (phone 262-375-4100), President of Stock America, explained that he had observed that many firms investigating new packages were considering using their retorts. He decided to represent suppliers of some of the new packages,such as plastic trays and retort pouches. Now Stock America offers a full line of retortable plastic containers in standard or custom sizes, as well as retort pouches from Israel that have a retortable zipper and are available with or without foil. Foil prevents heating pouches in a microwave, but a clear pouch requires a more-expensive barrier layer.

Finally, control systems for retorts are becoming more advanced, permitting real-time calculation of process lethality and optimization of temperature and time to achieve target processes without excessive heating. Traditionally, temperatures were recorded on circular charts,and any deviation from target temperatures and times could require reprocessing of the entire batch. Target temperatures were typically a few degrees higher than strictly required to allow for occasional dips due to changes in steam pressure. A mercury-in-glass thermometer was considered the most reliable temperature indicator. Temperature histories of test packs were used to establish a process schedule, which, once approved, became an absolute standard. Now, using inexpensive computers connected to each retort, real-time data can be used to calculate the accumulated heating and cooling effect, expressed as lethality or minutes at some reference temperature (250°Ffor low-acid foods). Processing can be terminated when the target is reached, and deviations are corrected on the fly.

Thermal processing is still the foundation of the processed foods industry, being applied to billions of containers of fruits, vegetables, soups, beverages, and meats every year.

Despite their long history, new products are still being developed in these categories, especially with the U.S. Dept. of Agriculture’s approval of the new organic seal, creating an opportunity for organic soups and sauces. Ready-to-serve soups and specialty sauces benefit from new packaging and rotary retorting.