Nonthermal Food Processing Is Heating Up

The food industry wants to ensure the safety of its products while maintaining quality. But while the maxim "heat kills germs" still holds true for food sterilization, scientists are exploring alternative treatments for lowering foodborne pathogen levels. Today, new technologies that are faster, cheaper, and less disruptive to quality than traditional thermal processing are increasingly common.

Under the guidance of research leader Howard Zhang, scientists in the Food Safety Intervention Technologies Research Unit—part of ARS's Eastern Regional Research Center (ERRC) at Wyndmoor, Pennsylvania—have investigated several nonthermal processing technologies. These include high-pressure processing, pulsed electric fields, radio-frequency electric fields, ultraviolet light, and irradiation.

"Some of these nonthermal techniques were developed here, but we have also tested and improved other technologies developed elsewhere," Zhang says. "Our work has improved food safety by enabling the food industry to make better decisions about how to reduce or eliminate foodborne pathogens."

For Liquids, High-Pressure and Electric Fields

High-pressure processing (HPP) treatment involves applying 80,000-130,000 pounds per square inch of pressure to a sample. Imagine the pressure in the greatest depths of the ocean, then multiply that by 10. Applying that extreme pressure for 2-5 minutes will kill most vegetative microorganisms—those that grow in foods under normal storage conditions.

ERRC researchers found that HPP treatment at 25˚C can significantly reduce *E. coli* populations in tomato juice and liquid whole eggs. Their research also suggested that multiple brief high-pressure treatments were more effective than one lengthy treatment using continuous pressure for the same total amount of time.

While HPP can eliminate vegetative microorganisms, it is not effective at killing microbial spores. And at 5-10 cents per pound, it is too pricey to be practical.

"We hope to develop pressure technology that is cheaper and more effective against spores," Zhang says.

Another technology that ERRC scientists have improved uses pulsed electric fields (PEF) to kill yeasts, molds, and vegetative bacteria in liquid foods. These intensive electric pulses break down the cell membranes of the microorganisms.

One study explored the feasibility of using PEF in making shelf-stable salad dressings. A model salad dressing for the study was formulated by Kraft Foods. ARS scientists inoculated the dressing with *Lactobacillus plantarum,* a very heat-resistant spoilage bacterium. The sample was then treated either by PEF alone or by PEF followed by mild heat. While PEF treatment alone significantly reduced *L. plantarum,* the dressing retained microbial shelf stability only when refrigerated. PEF plus mild heat exposure, however, produced shelf stability at room temperature.

Another study subjected applesauce samples to PEF followed by mild heat treatment. The processed applesauce was aseptically packed into plastic cups and stored at room temperature. Evaluations indicated that the processed applesauce maintained high sensory quality during 470 days of storage. That's a longer shelf life than is currently used in commercial practice. This research demonstrated that following PEF with mild heat may be used in producing high-quality, shelf-stable applesauce products.

Like the PEF process, radio-frequency electric field (RFEF) technology subjects liquid foods to high electric fields. But this procedure—developed at ERRC—uses a continuous alternating current power supply, which costs less than a PEF pulse generator.

In one study, ARS scientists applied RFEF for 3 seconds at 60˚C to an apple juice sample inoculated with *E. coli*. The electrical cost of RFEF processing was about 1 cent per deciliter (10.5 quarts), and the procedure was more effective than conventional heating under the same conditions.

UV or Not UV? Ultraviolet Light and Irradiation

ERRC has also investigated ultraviolet (UV) light and irradiation technologies as alternatives or complements to thermal processing.

Scientists used UV processing on an apple cider sample

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Food microbiologist Dike Ukuku (left) and engineer Joseph Sites evaluate effects of high-pressure processing on microbial stability of tomato juice and liquid eggs.

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In studies of methods to pasteurize liquid foods such as apple cider without using heat, research leader Howard Zhang (left) and chemical engineer David Geveke develop and evaluate pulsed electric field and radio frequency electric field treatments.

that had been inoculated with bacteria. Heat and chemical treatments can destroy bacteria within cider, but they generally alter the flavor. The UV treatment reduced populations of *E. coli* and *Listeria innocua* by more than 99 percent without changing the liquid's flavor. Scientists believe UV processing has potential to improve the safety of apple cider and extend its shelf life without diminishing its quality.

Could UV processing provide safe liquid egg products too? Extensive thermal pasteurization, though effective for other types of food, damages the functional properties of egg whites, so USDA's Food Safety and Inspection Service asked ERRC to investigate.

ERRC researchers combined UV and heat treatments to kill *E. coli* in liquid egg whites. Whites infected with *E. coli* O157:H7 were processed using a simple UV apparatus consisting of a low-pressure mercury lamp surrounded by a coil of UV-transparent tubing. The scientists found that UV treatment at room temperature can significantly reduce the heat subsequently required to pasteurize liquid egg whites.

Irradiation exposes food to a low level of ionizing radiation to kill bacteria, molds, yeasts, parasites, and other microorganisms that can lead to food spoilage and illness if untreated. ERRC is the only federally funded and operated food irradiation research facility in the United States.

Over the last 25 years, studies have shown that eating irradiated foods poses no increased health risks for consumers. ERRC research findings have enabled federal regulatory agencies to establish standards to ensure safety and quality of irradiated products like fruit, vegetables, juice, meat, and meat substitutes. At 3-5 cents per pound, irradiation is slightly more expensive than thermal processing, but its success in deactivating spores and other microorganisms has made it an option for the food industry.

Foodborne pathogens are varied and numerous, but thanks in part to contributions from ERRC scientists, knowledge of pathogen prevention improves constantly, and with it, the safety of the nation's food supply.—By **Laura McGinnis,** ARS.

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Food microbiologist Kathleen Rajkowski evaluates how well a pulsed ultraviolet light treatment inactivates bacterial pathogens on the surface of test media.