Posthar-vest Food Safety Innovations Improve Beef Safety

PEGGY GREB (D621-1)

Microbiologist Terry Arthur (left) and USMARC director Mohammad Koohmaraie examine petri dishes for *Salmonella* growth.

Even in the United States—which has some of the highest food safety standards in the world—millions of Americans contract foodborne illnesses every year. Many of these come from microorganisms on undercooked meat or in unpasteurized milk. While most of these illnesses are fairly mild, some can be serious—or even fatal.

Fortunately, our food is getting safer all the time. Avoiding undercooked meat and unpasteurized milk is the best way for consumers to protect themselves, but it's not the only method. Eliminating or reducing the pathogen threat before products reach the marketplace improves their safety even further.

A highly publicized *E. coli* outbreak in 1993 increased national awareness of foodborne pathogens and prompted an immediate response from the meat-processing industry and the government. Over the past decade, researchers at ARS's Roman L. Hruska U.S. Meat Animal Research Center (USMARC) have developed technologies and procedures to control potentially dangerous pathogenic microorganisms, making U.S. meat safer for consumers throughout the world.

Hide Intervention

The Centers for Disease Control and Prevention (CDC) attributes about 73,000 illnesses and 60 deaths every year to *E. coli* O157:H7—one of the Shiga toxin-producing *E. coli* (STEC) and the variety responsible for the 1993 outbreak.

Though *E. coli* O157:H7 can harm humans by deactivating ribosomes and destroying kidney cells, cattle can host them without harm. ARS research showed the pathogen tends to gather on cattle hides, which becomes a problem if meat is contaminated during hide removal. USMARC researchers realized that removing pathogens before removing the hides would be a very effective way to reduce the risk of carcass contamination.

Over the last 10 years, the beef-processing industry has spent more than $750 million to increase the safety of beef products. Much of the effort has focused on ways of removing contaminants from carcasses, says USMARC director Mohammad Koohmaraie.

Koohmaraie and his colleagues—microbiologists Terry Arthur and Mick Bosilevac and food technologists Steven Shackelford and Tommy Wheeler—developed a practical, effective cattle-washing system to reduce on-hide pathogen levels. The beef industry implemented chemical decontamination based on those tests and saves millions of dollars a year as a result.

Before this, however, researchers first experimented with chemical dehairing. This process proved very effective—reducing bacterial prevalence from 50 percent to 1.3 percent in one study—but it was prohibitively expensive. Because it seemed to be impractical for widespread industry adoption, the researchers turned their efforts to chemical decontamination.

In this process, the hide-on carcass is cleaned in a high-pressure-water washing cabinet to remove excess organic matter, then sprayed with an antibacterial compound. The scientists found several effective compounds, including sodium hydroxide, Chlorofoam, trisodium phosphate, phosphoric acid, acidified chlorine, ozonated water, electrolyzed oxidative water, and cetylpyridinium chloride.

"When companies decide which compound to use, they must also consider cost, waste disposal, and worker safety," Wheeler says. "We tested various compounds to provide alternatives for companies to select from."

In field trials, subjecting live cattle to a water wash and two applications of a chemical compound reduced the number of meat samples that tested positive for O157:H7 from 23 percent to 3 percent.

Industry Incorporation

The USMARC scientists collaborated with several industry partners while developing and transferring this technology,

including the National Cattlemen's Beef Association, Cargill Meat Solutions, Harris Ranch Beef, Future Beef Operations, Tyson Fresh Meats, Inc., Swift & Company, Electric Aquagenics Unlimited, Ozone International, and Safe Foods Corporation.

Koohmaraie estimates that about 40 percent of the feedlot-raised beef harvested in the United States undergoes hide-on carcass-washing treatment, a development that benefits both beef companies and consumers.

"Cargill Meat Solutions spent millions to install hide-washing cabinets in each of the company's six processing plants. Now with fewer samples testing positive for *E. coli*, they save millions of dollars every year," Wheeler notes.

"Like most of the industry, Cargill tests its ground-beef products, and if they are found positive for *E. coli* O157:H7, they will not enter commerce," Koohmaraie explains. The fewer products they discard, the more money they save.

Decreasing the pathogens in beef products has also reduced the incidence of related foodborne illness. The U.S. Department of Agriculture's Food Safety and Inspection Service reported that the incidence of *E. coli* O157:H7-positive ground beef samples collected fell by 43.3 percent after the beef industry started using the washing cabinets. The CDC also noted significant reductions in illnesses caused by *E. coli* and the pathogens *Listeria, Campylobacter, Yersinia,* and *Salmonella*.

E-Beam Irradiation

How else has USMARC research improved beef production? One recent study targeted ground beef, which poses particular risks if contaminated by a pathogen because it is mixed so thoroughly. Heat can kill these pathogens, but because the risk of subsurface contamination is higher with ground beef, the Food and Drug Administration recommends cooking it until the *internal* temperature reaches 160˚F.

The USMARC researchers examined the effectiveness of using low levels of radiation on beef carcasses before cutting to reduce pathogens in ground beef made from it. High-penetration, high-energy radiation is a safe method of killing bacteria, but it can alter the beef's odor and flavor. Could low-dose, low-penetration electron beam (E-beam) irradiation—which only penetrates 15 millimeters below the surface—offer an effective alternative?

The team discovered that this technology does effectively reduce pathogens on the carcass surface and had little to no influence on the smell or taste of the meat when it was used to make stir fry or ground beef.

A Count You Can Count On

Koohmaraie, Arthur, and Bosilevac, along with USMARC microbiologists Dayna Brichta, Michael Guerini, and Norasak Kalchayanand, have also developed techniques to evaluate the effectiveness of their pathogen-reduction practices. Recognizing that there were no reliable methods to count pathogens within a sample, the beef-processing industry identified that as a priority. USMARC scientists responded by developing two methods for counting pathogen numbers—referred to as "enumeration"—on cattle hides and carcasses and in feces and ground beef.

In addition to enabling beef processors to evaluate the effectiveness of the methods they've adopted to reduce pathogen levels, enumeration provides information that can be used for making risk assessments for the public.

In the past, tests could spot the presence of a pathogen in a sample but not the amount of it. The tests operated through a process that caused the pathogens to grow. But because the microbes didn't grow at a steady or predictable rate, it was impossible to tell how many had existed before the tests were run.

One of USMARC's enumeration methods involves using a "spiral plater," a special instrument that Arthur compares to a petri dish on a turntable. Spiral plating

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Ground beef samples are prepared for enumeration of bacteria by microbiologists Mick Bosilevac and Dayna Harhay.

Low-dose, low-penetration **E-beam** irradiation effectively reduces pathogens on the carcass surface and has little to no influence on **smell** or **taste** of meat used to make stir fry or ground beef.

works best on samples where a high pathogen load could be expected, Arthur says, such as fecal matter or hides. The test uses a calibrated syringe to distribute the sample through a stylus onto an agar plate. The plate rotates as the stylus distributes the sample from the center of the plate to the edges.

"The microbes are concentrated at the center. Toward the edges, the sample gets a lot thinner, which allows counting bacteria over a very large range," Arthur says.

The second method uses a hydrophobic (water-repelling) grid printed on a membrane filter.

"This method works better for carcass and ground beef samples that have low numbers of pathogens, if any," says Brichta. A sample is placed on the filter. Then a vacuum sucks the liquid from the sample through the filter, leaving the bacteria on the grid. Both methods enable scientists to count bacterial colonies and identify the target organisms within the sample.

Enumeration costs about $100 per sample if non-USMARC methods are used. With USMARC methods, the cost drops to about $2 per sample. Currently, these tests quantify *Salmonella* and *E. coli* O157:H7, but USMARC researchers hope to extend the technology to other pathogens.

The United States consumes more than 27 billion pounds of beef every year and exports another 450-500 million pounds abroad. This multibillion-dollar industry owes its success in part to the research projects that ensure that our country's beef producers are providing the safest, highest quality product possible.—By **Laura McGinnis,** ARS.

This research is part of Food Safety, an ARS National Program (#108) described on the World Wide Web at www.nps.ars.usda.gov.

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While acting research leader Tommy Wheeler records a cow's identification number, food technologist Steven Shackelford uses a moist sponge to obtain a microbe sample from the cow's hide.

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Right: After the cow's hide was sampled (see above), the sponge has been coated with a representative sample of the contaminants present on the animal's hide, including hair, soil, feces, and microorganisms.

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Mohammad Koohmaraie (left) and Terry Arthur review a gel image of PCR results to identify virulence factors in *E. coli* O157:H7 isolates from cattle hide samples.