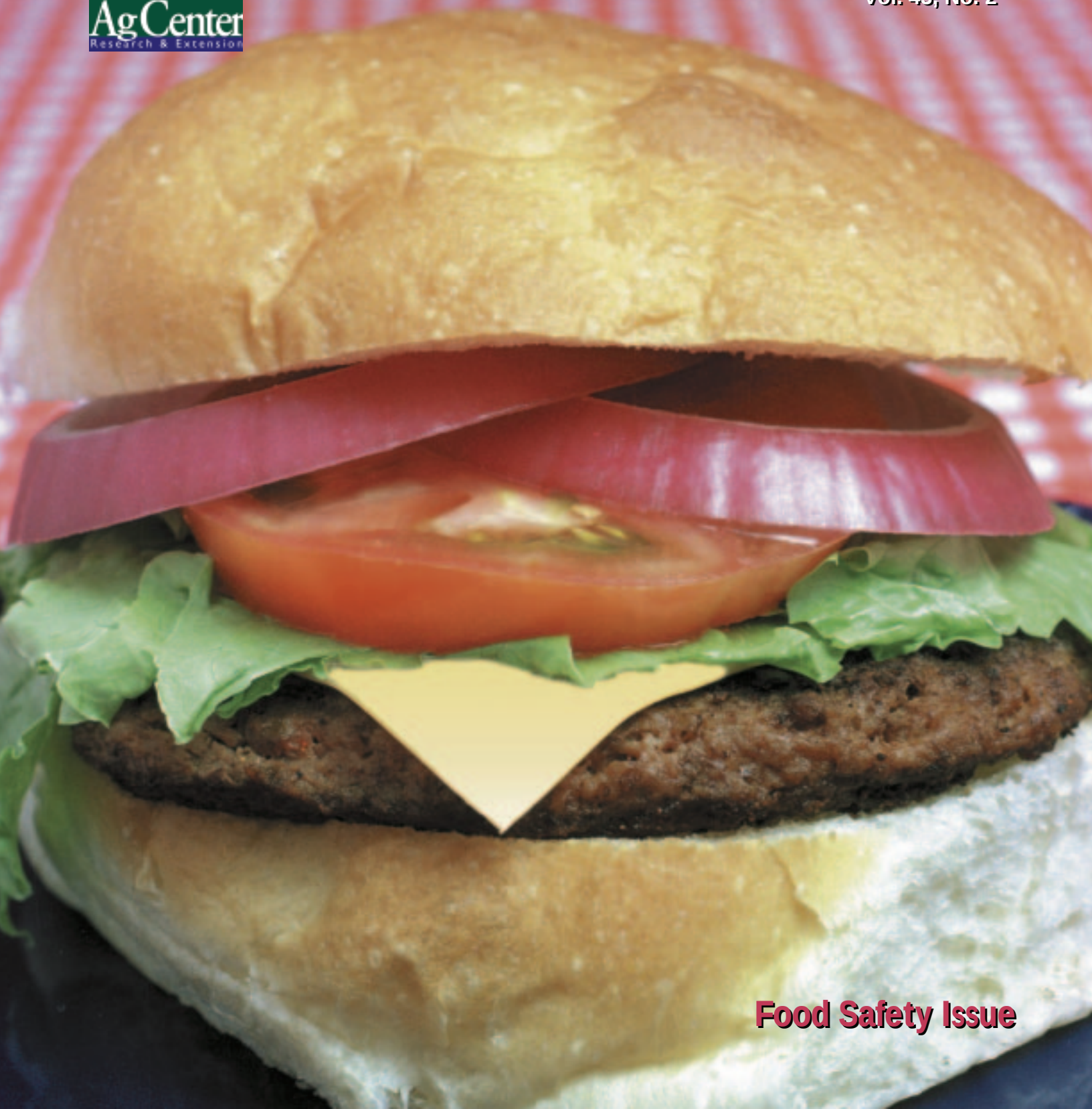


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Food Safety Issue

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The Louisiana Agricultural Experiment Station provides equal opportunities in programs and employment.

Photo by Mark Claesgens



The LSU AgCenter sponsored an event at the state capitol in the spring of 1998 to help acquaint people with the various research activities of the Louisiana Agricultural Experiment Station. The oysters being served have been pasteurized using the procedure developed through research. Left to right are Noble Ellington, John Koch, Nick Felton, Charlie Smith and Michael "Hollywood" Broadway of the Acme Oyster House in New Orleans.

Scientists develop process that saves oyster industry

A partnership between scientists at the LSU Agricultural Center and entrepreneurs in Louisiana's oyster industry has resulted in a revival of the Gulf Coast raw oyster. Louisiana had been a key supplier of this product. But its marketing was threatened by fears that a deadly microorganism, named *Vibrio vulnificus*, might be lurking inside the shell. The U.S. Food and Drug Administration had required the oysters to carry a warning — strong enough that people did not want to buy them. Research scientists with the LSU AgCenter's Department of Food Science in cooperation with an industrial firm, AmeriPure Oyster Processing Co., solved the problem. They came up with a heating process, similar to the pasteurization of raw milk, that killed the offending microorganism without hurting the texture or flavor of a raw oyster. The process works so well that the FDA has lifted the warning label on pasteurized raw oysters. AmeriPure owns the patent for the process. ■

Photo by Mark Claesgens



Dr. Douglas Park, left, headed a team of scientists that worked with private industry to develop a pasteurization process for raw, in-shell oysters. The oysters are rendered safe to eat with no harm to their flavor or texture. At his right is the renowned musician Pete Fountain from New Orleans, who helped take part in the event at the state capitol.



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Cover photo by John Wozniak

LSU AgCenter researchers are working on ways to keep the hamburger supply safe by using ozone. See page 18. More about this research will appear in the Fall 2000 issue.

The Concept of Food Safety

Douglas L. Park and Carlos E. Ayala

Food consumption plays two roles in human development: nutrition and disease prevention. Foods provide not only protein, fats, vitamins, minerals and other constituents essential for growth, but also components necessary for prevention of certain diseases. For proper growth and mental development, people must eat a balanced diet. Food is both abundant and generally recognized to be safe, but some human illnesses can be traced to foods. The causes of these illnesses may be natural constituents of foods, such as contaminating pathogenic bacteria, or chemicals in minute amounts that have been added for other purposes, such as pesticides for insect control before harvest or food additives for enhancing food quality and safety.

Illnesses associated with foods are rare. When they occur, however, the adverse effect on human health and the food supply availability can be significant. Studies conducted in research laboratories play an important role in identifying the sources of foodborne health risks and the development of procedures and products that reduce the magnitude and significance of foodborne hazards. These studies help provide the assurance of a safe, wholesome food supply. Industry, academia and public health agencies work hand-in-hand to reach this goal.

Components of Foodborne Hazards

Foodborne hazards can be classified into pathogenic organisms, intrinsic components and chemicals. The primary categories of foodborne pathogenic organisms are bacteria, viruses and

parasites. Problem pathogens that have been featured in the news in recent years include *Escherichia coli* (*E. coli*) O157:H7 in meat and apple juice, *Salmonella* in eggs and on vegetables, *Cyclospora* on fruit, *Cryptosporidium* in drinking water and hepatitis A virus in frozen strawberries. Numerous methods have been developed and are used to reduce risks posed by pathogenic microorganisms including pasteurization, cooking, addition of preservatives and proper storage conditions.

Intrinsic food components include nutritional factors and thousands of contaminant compounds naturally present in foods. The intrinsic component hazards in the food supply associated with nutritional factors can be either deficiencies or excesses. Pellagra, scurvy, goiter, rickets and beriberi are examples of the former, and toxicity from excessive fat-soluble vitamins and minerals illustrates the latter. On the other hand, natural contaminants include those occurring in foods of plant origin, such as the oxalates in spinach and the glycoalkaloids in potatoes. Eating a nutritious diet including mixed and varied components can minimize most of these problems.

Hazardous chemicals in foods include naturally occurring toxicants, agro-industrial contaminants and food additives. The naturally occurring toxicants pose the greatest risk, and food additives the least. Naturally occurring toxicants are chemicals from the natural environment that occur in foods and animal feeds, including mycotoxins and algal metabolites, aquatic biotoxins, phytoalexins, intrinsic components of plants, bacterial toxins, cyanobacterial toxins and food decomposition components. Food additives pose relatively little risk because of intensive testing required by public health agencies before approval for food or animal feed use. Food additive categories in the United States are classified as direct, indirect, generally recognized as safe (GRAS) substances, pesticide residues and animal drug residues. Major efforts are under

way to identify the risks posed by these compounds, develop cost-effective measures to remove the risk and provide important information to consumers on the role they can play in promoting food safety.

Risk Assessment

Risks associated with food hazards and chemical exposure, although not common, make the public more aware of foodborne hazards in their daily lives.

Once a specified hazard has been identified as causing a particular health effect, a risk assessment is conducted. The goal of the risk assessment is to estimate the risk to humans caused by the potential hazard. A risk assessment is conducted following three basic steps: hazard evaluation, human exposure evaluation and risk determination or estimation. Once these have been determined, a risk management strategy is developed to reduce the risk to the lowest practical level, while trying to maintain an adequate, wholesome food supply.

Using aflatoxin contamination in agricultural commodities as an example, the initial step collects the available information about the level and extent of the contamination as well as the toxicity potential. Since the aflatoxin dose will have an effect on the risk, nature and severity of toxicity, this step also includes a dose-response evaluation. For each determined form of toxicity caused by aflatoxin, the dose-response evaluation will help establish the quantitative relationship between dose and risk of toxicity in the range of doses that have been or might be experienced by consumers. The assembled data are critically evaluated to determine the forms of toxicity that may be caused by aflatoxin and to determine how vulnerable human beings may be to its toxic effects under certain conditions.

The second step, human exposure evaluation, identifies the susceptible commodity or product and contamination levels, the target population, the dose of aflatoxin received by individuals

Douglas L. Park, former Professor and Head and now with the U.S. Food and Drug Administration, and Carlos E. Ayala, Postdoctoral Research Associate, Department of Food Science, LSU Agricultural Center, Baton Rouge, La.

consuming the products and the duration of exposure. Since not all individuals in the population are exposed to the same doses, the dose ranges or number of people exposed to each of several different doses need to be determined.

The final step is the risk determination or estimation, which uses the toxicological and exposure information to estimate the likelihood that an adverse health effect will occur in the population. Despite its limitations, risk assessment is the best approach for addressing safety, health and environmental risks. It analyzes and evaluates limited information, while eliminating the guesswork in decision-making, and identifies priority areas for further research.



Photo by Mark Claesgens

Dr. Douglas L. Park headed a team of LSU AgCenter scientists that helped develop a pasteurization process to make raw, in-shell Gulf Coast oysters safe to eat. (See page 2.)

Risk Management

Risk management is the process of using information obtained in the risk assessment procedure and weighing policy alternatives to select the most appropriate regulatory action. Unlike risk assessment, risk management is a highly subjective scheme, because it involves preferences and attitudes not part of the risk assessment process. Also, a high degree of public acceptance is essential for the success of risk management decisions.

In principle, risk management involves the identification and appraisal of available management alternatives, the selection of the best alternatives, and the implementation, monitoring and enforcement of the selected alternatives. Some practical risk management alternatives contributing to food safety include:

- Establishment of regulatory limits.
- Monitoring of food products before and during harvest and processing.
- Screening and testing of products in commercial channels.
- Developing decontamination procedures.
- Diverting products to less risky uses.

Food Safety Programs

Food safety programs are designed to limit exposure to foodborne risks. Where feasible, prevention is the best policy. For illustrative purposes, risks associated with aflatoxins will be used to demonstrate how effective food safety programs can reduce human exposure to those naturally occurring toxicants. Cottonseed, corn, peanuts and tree nuts are the commodities most adversely affected by aflatoxin contamination. Pre-harvest invasion of the toxin-producing organism *Aspergillus* sp. and its subsequent production of the toxin are unavoidable. Disallowing total availability or sale of products with potential contamination is not practical, particularly when the products are diet staples or have high nutritional value. If contamination occurs, the hazard associated with the toxin must be removed if the product is intended for human or animal consumption.

Before an effective food safety monitoring program can be set up, it is necessary to understand how the products become toxic and to have the analytical tool to identify high-risk products. An optimum food safety monitoring program for aflatoxins has three basic components: (1) monitoring agricultural commodities for aflatoxins before or during harvest, (2) establishing regulatory limits to exposure and (3)

screening in commercial channels to identify and separate toxic commodities.

When regulations for aflatoxin were first established by the Food and Drug Administration (FDA), the toxicological knowledge available at that time confirmed an adverse health effect on livestock and a potential health risk for humans. A human food and animal feed safety program has been established to minimize human exposure to aflatoxin and its metabolites, protect animal health and provide an adequate food supply. This led to regulatory levels that vary according to the intended end-use of the product.

This *Louisiana Agriculture* issue provides a snapshot of research efforts under way in the LSU Agricultural Center to minimize risks associated with the consumption of foods. These include alternative food packaging to control the growth of pathogenic bacteria, the pasteurization of raw in-shell oysters to reduce risks posed by *Vibrio* species, the implementation of a rapid microbial detection laboratory to support enhanced food quality efforts and the mandated hazard analysis and critical control points (HACCP) program, the development of a bar code system for continuous monitoring of pathogenic bacteria in muscle foods and the evaluation of new techniques to reduce aflatoxin levels in corn. ■

Training program helps keep seafood safe

Michael W. Moody



Photo by Mike Moody

Using HACCP principles, seafood processors document the safety of products. Sometimes this includes handling and storage practices at harvest.

In December 1996, the U.S. Food and Drug Administration (FDA) issued a requirement that all seafood must be processed using Hazard Analysis and Critical Control Point (HACCP) principles. The intent of the requirement is to increase food safety and consumer confidence.

The seven principles of HACCP are:

1. Conduct a hazard analysis and identify preventive measures.
2. Identify critical control points (CCP).
3. Establish critical limits.
4. Monitor each CCP.
5. Establish corrective actions.
6. Establish a record-keeping system.
7. Establish verification procedures.

Although the use of HACCP principles in food processing has become more important in recent years, the concept, as applied to food manufacturing, has been around for more than 35 years. The Pillsbury Company initially used the principles to manufacture food for the U.S. space program in the early 1960s. By 1974, low-acid canned food manufacturers were HACCP-regulated to protect consumers against botulism.

Over the years, HACCP has proved to be an effective, systematic way to ensure safe food to consumers. The U.S. Department of Agriculture requires HACCP in the processing of red meats and poultry. Today, HACCP is the principal food safety tool used by regulatory agencies.

HACCP is effective because it requires seafood processors to identify food safety hazards and then to initiate actions that prevent the hazard from affecting the seafood. Using HACCP principles allows for a preventive rather than reactive food safety system. For example, processors of cooked, ready-to-eat seafoods such as crabmeat, crawfish meat and shrimp know that bacteria associated with the live seafood must be destroyed before the product can be provided to consumers. Using HACCP principles, processors determine that achieving a specific minimum temperature at the cooking step will destroy the bacteria that may cause illness. Using HACCP in food processing is not a zero risk strategy, but when performed correctly, seafood processors and consumers can be confident that the hazards have been eliminated.

A key element in HACCP implementation is training. So important is training that the seafood regulation requires that certain HACCP functions be performed only by "an individual who has successfully completed training in the application of HACCP principles." The regulation further states that this training must be "at least equivalent to

that received under standardized curriculum recognized as adequate" by the FDA.

HACCP represents a major change for seafood processors in many ways. First, they must keep records for designated processing steps to ensure control over identified hazards. In addition, these records are used as part of the inspection process by regulatory agencies. Second, processors must have a good understanding of potential hazards associated with seafoods and the science involved in controlling those hazards.

Generally, hazards fall into three categories: biological, chemical and physical. Consequently, processors must understand such concepts as the time and temperature relationships needed to destroy or minimize the effects of biological (microbial) hazards, the natural and man-made toxins and chemicals that can contaminate foods and ways to prevent foreign objects from contaminating foods.

In 1994, a National Seafood HACCP Alliance was formed in anticipation of a HACCP training requirement as part of future regulations. The initial group was composed of representatives from governmental agencies, industry and university programs, including an LSU Agricultural Center representative. The overall goal was to increase the safety of domestically processed and imported seafoods consumed in the United States through a focused HACCP training and education program.

Michael W. Moody, Specialist, Department of Food Science, LSU Agricultural Center, Baton Rouge, La.

The Alliance estimated that there were more than 5,000 domestic-licensed seafood processing firms. There are nearly 500 individual seafood processing permits in Louisiana alone. In addition, the Alliance estimated that nearly 3,000 state and federal seafood inspectors and other individuals would seek training.

Working in concert with FDA, the Alliance developed and published a core curriculum, which has become the standard referred to in the regulation. A manual, now in its second edition, is more than 200 pages long and is available in both English and Spanish. The Alliance also developed a protocol for teaching the course. The course is three days long, and all successful students receive a Certificate of Completion from the Association of Food and Drug Officials (AFDO). This certificate shows proof to regulatory agencies that an individual has met the training requirement.

In October 1996, the LSU AgCenter offered the first seafood HACCP class to a group of 28 processors. Since that time, the AgCenter has provided 24 classes statewide, with 921 students successfully participating in the training. Representatives from the



Photo by Mike Moody

HACCP requires that seafood processors control biological, chemical and physical hazards. Processors must be sure that proper cooking times and temperatures have been used to eliminate pathogenic bacteria, which are a biological hazard.

FDA and the Louisiana Office of Public Health participated in teaching every course in Louisiana.

Nationally, there have been 364 basic courses offered by other universities and consulting groups to 9,701 students. Internationally, the numbers are 63 basic courses and 1,170 students.

As a result of this effort, most Louisiana processors have a HACCP-trained employee responsible for writing and implementing a HACCP plan. However, because of turnover of personnel in processing facilities and the start-up of new facilities, the

AgCenter will continue training but on a reduced scale. An individual needs to take the course only once.

Because of the popularity of the HACCP training, seafood processors, including those from Louisiana, have requested a complementary course dealing specifically with plant sanitation. The Alliance has undertaken this challenge and has prepared a one-day course titled Sanitation Standard Operating Procedures (SSOP) training. This course will address issues associated with cleaning and sanitizing of the facility, employee sanitation practices and plant design.

As in the basic HACCP training course, a manual has been developed along with a course protocol. Successful participants will receive certificates from AFDO. There is no requirement in the HACCP regulation that seafood processors receive sanitation training, but many seafood processors have expressed a desire for the course. The LSU AgCenter will offer the course beginning in the summer of 2000.

The Louisiana seafood processing industry, working hand-in-hand with the LSU AgCenter, is meeting the HACCP challenge. ■



Photo by John Wozniak

HACCP affects the entire processing facility. Employees must be aware of their responsibilities to produce a clean product and to use recommended sanitary practices. A HACCP-trained individual must document daily sanitation practices.

New barcode will help monitor food safety

Carlos E. Ayala and Douglas L. Park

Throughout the various phases of the food production and processing system, opportunities for contamination exist. Reliable laboratory and field methods are necessary to rapidly detect and trace the source of contamination. To enhance early detection and continuous monitoring of foodborne disease nationwide, new and improved diagnostic tools are needed. They should provide rapid, cost-effective testing for pathogens in food animals, agriculture and aquaculture products, animal feeds and processed food products.

One new tool is called the Food Sentinel System (FSS). Unlike other systems that involve the collection of a sample at a given time and place and subsequent sample preparation and analysis, the Food Sentinel System remains with the product and performs a continuous tracking for product safety. This helps alert food processors, dis-

tributors, public health officials and consumers of the presence of pathogenic bacteria of human health concern in fish, poultry, meat and some liquid products.

The Food Sentinel System is based on a solid-phase immunobead assay (S-PIA) and antibody sandwich principles modified to allow the continuous flow and exposure of product juices and contaminating microorganisms. It is an immunochemical method linked to a uniquely designed commercial universal product code (UPC) bar system.

As contaminants such as *Salmonella* sp., *Escherichia coli* 0157:H7, *Listeria monocytogenes* flow through the FSS, they bind to colored immunobeads (specific-pathogen antibodies bound to black latex microspheres) that, in turn, migrate to be captured by a second specific antibody. This antibody is attached to a membrane forming part of the bar code system. The presence of the

contaminating bacteria is evident by the formation of a localized dark bar on the membrane as a result of the immunobead-antigen complex agglutinating on the capture antibody location.

The dark bar modifies the appearance of the overlying bar codes in two ways. The purveyor's bar code is rendered unreadable by any scanner, while the lower

FSS bar code indicating contamination becomes readable from the added bar. The membranes are designed to allow entry of pathogenic bacteria, prevent entrance of interfering substances and maintain the immunobead-bacteria complex inside the system.

Bar code scanning can be done with hand-held devices or be automated as part of packaging, transportation, storage and retail operations. Scanners can be programmed to read the type of contamination, product and the date and location of the reading. In the absence of scanning devices, the consumer at home can observe the appearance of a new symbol on the bar code signaling contamination.

The Food Sentinel System is inexpensive. Its usefulness in the food industry is greater than conventional microbial testing because it continuously monitors microbial presence from slaughter to the processing plant to the consumer. Product and economic losses are, therefore, reduced. Its universal presence is better than conventional monitoring by random sampling.

Research at the LSU Agricultural Center's Department of Food Science will help bring the Food Sentinel System into actual use, which is expected in the next few years. Contributions of LSU AgCenter research include the following:

- Concept and adaptation of S-PIA to the optical scanning bar code system.
- Evaluation and selection of system solutions.
- Selection of membranes, latex beads, structural films and surfaces, absorbent pads and filters.
- Evaluation and optimization of the migration process for optimal flow.
- Simplification and reduction of system dimensions.
- Testing under natural packaging conditions.
- Testing under diverse physical conditions.
- Testing additional structural materials. ■

Acknowledgment

The Food Sentinel System is a registered trademark of SIRA Technologies, which helped with the funding of this research.

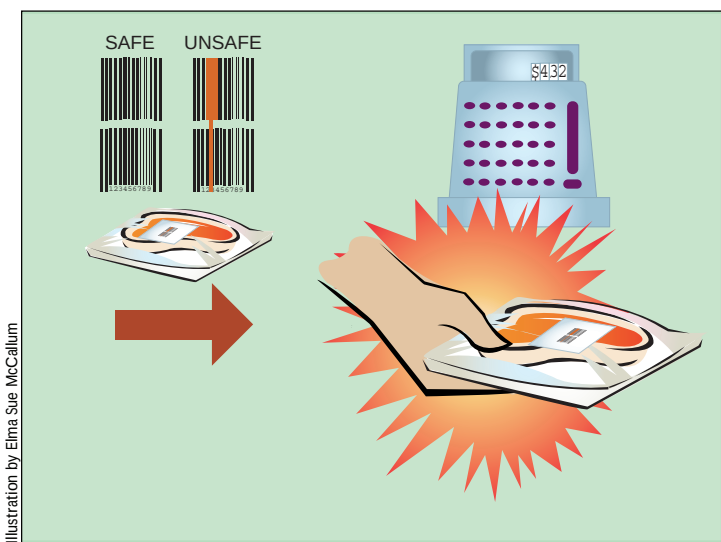


Illustration by Elma Sue McCallum

The Food Sentinel System uses a bar code to help detect pathogens. This bar code travels with the product from processing to retail, and a colored bar appears if there is contaminating bacteria present.

Carlos E. Ayala, Postdoctoral Research Associate, and Douglas L. Park, former Professor and Head, Department of Food Science, LSU Agricultural Center, Baton Rouge, La., and now with U.S. Food and Drug Administration.

Scientists develop rapid, user-friendly test kit for marine toxins

Douglas L. Park and Carlos E. Ayala

Ciguatera fish poisoning is a type of food poisoning caused by ingestion of certain tropical and subtropical marine fish that harbor natural toxins originating from microscopic algae (dinoflagellates). The illness is widespread in the tropical Caribbean, subtropical North Atlantic and the Pacific regions. More than 400

have been previously exposed are more susceptible and react to lower levels of the toxin. Additionally, the severity of the symptoms increases with subsequent ingestions of ciguatoxic fish.

The major source of the toxins is a group of dinoflagellates, which are planktonic unicellular aquatic microorganisms. Most, like plants, contain chlorophyll for photosynthesis and are primary producers of energy in the ocean food chain. Dinoflagellates show traits of both animals and plants. Zoologists classify them as protozoans and botanists as algae. They can sometimes reproduce in enormous numbers, called a bloom. Certain species produce a strong nerve toxin and are responsible for the

immunobead assay. Before the development of the Ciguatetect kit, there was no test available which could be conducted outside of a laboratory. This test will allow fishers, processors and individuals at various stages in the food chain to detect the presence of ciguatoxins.

The Ciguatetect kit is a qualitative method for detecting the presence of specific antigens, such as toxins, on a special membrane attached to a plastic strip for support. The suspected sample (tissue or its extract containing the toxin) is immobilized on the membrane and exposed to an immunobead solution. This solution is prepared by combining an antibody specific to the toxin with microscopic colored latex beads. This process allows the antibody to be bound to the beads' surface. The resulting immunobeads are then capable of binding to the toxin whenever present on the membrane. In running the test, the specific immunobeads get bound to the immobilized antigen within a few minutes, resulting in a color change on the membrane that indicates the presence of the antigen. The assay can be considered semi-quantitative, since the intensity of the color reflects the antigen magnitude in the sample.

Test procedure

The Ciguatetect test kit procedure for ciguatera fish poisoning toxins in whole fish is simple and rapid. The user normally makes a deep incision about 1 inch behind the head of the sample fish and inserts the membrane end of the test strip. The strip is placed on a flat surface until the membrane is dry (about 5 minutes). The membrane end of the test strip is immersed in methanol solution

Douglas L. Park, former Professor and Head and now with the U.S. Food and Drug Administration, and Carlos E. Ayala, Postdoctoral Research Associate, Department of Food Science, LSU Agricultural Center, Baton Rouge, La.

Detecting the toxin

There has been increasing interest in development of a simple, rapid and inexpensive way to detect ciguatoxin and related toxins. Since the early 1990s, HawaiiChemtect International (Pasadena, California), in association with LSU Agricultural Center researchers, has been working on development of a commercial kit named Ciguatetect, which involves an innovative rapid solid-phase



After a 10-minute incubation in immunobead solution, blue coloration of the membrane containing a sample denotes the presence of a specific marine biotoxin.

different fish species, including amberjack, moray eel, barracuda, Spanish mackerel, triggerfish, snapper, parrot fish, surgeon fish and grouper have been associated with ciguatera outbreaks.

Ciguatera exhibits itself in a variety of ways with many symptoms ranging from gastrointestinal to neurological to cardiovascular disorders. The symptoms last from an initial duration of 14 to 21 days, to months or even years. The onset of symptoms usually occurs within 3 to 5 hours after eating a toxic fish. General symptoms are flu-like. Prolonged cases may also exhibit depression and phobia development. Low blood pressure, reduced blood volume, coma or death may occur. Susceptibility to the toxins and severity of the symptoms vary greatly among individuals because of the possible presence of several different toxins. Immunity does not develop. Evidence suggests that individuals who



The square membrane attached to the end of the supporting plastic strip holds the test sample, negative control or positive control, before immersion in blue immunobead solution specific for a marine biotoxin responsible for fish or shellfish poisoning.

Introducing 'Earl'

Scientists develop new rice variety

Scientists at the LSU AgCenter have developed a new medium-grain rice variety, named Earl, that offers improved yield and disease resistance.

Earl has "inherently very good yield potential," according to Dr. Steve Linscombe, rice breeder at the LSU AgCenter's Rice Research Station at Crowley.

"This new variety addresses specific issues," Linscombe said. "It has better resistance to blast disease and is a little higher yielding than Bengal, a variety we introduced in 1992."

Bengal is the most widely grown medium-grain rice in Louisiana – with about 90 percent of the 38,000 to 40,000 acres of medium-grain rice in Louisiana – and it also dominates the Arkansas medium-grain production in about the same proportion, according to Dr. Bill Brown, associate vice chancellor of the LSU AgCenter.

Rice farmers produced nearly \$276 million worth of rice at farm prices in 1998, while value-added processing supplied another \$82 million to the Louisiana economy in 1998, according to the LSU AgCenter's Louisiana Summary of Agriculture and Natural Resources.

"The variety is named in memory of Earl Sonnier, who was the director of foundation seed production at the Rice Research Station for many years as well as a recognized authority on rice seed production internationally," Linscombe said.

The Rice Research Station has produced 250 hundredweight of Earl as foundation seed for 2000, said Dr. Joe Musick, the station's resident director. The seed has been allocated to growers who will produce seed for the 2001 crop. ■ **Rick Bogren**

and then allowed to dry for about 5 minutes. This step helps the toxin migrate from the tissue to the membrane structure where it is immobilized. The membrane end of the test strip is immersed in the immunobead solution and left undisturbed for 10 minutes. No color on the membrane is indicative of negative toxicity, and it is given a score of zero. The presence of color on the membrane denotes the presence of ciguatoxin in the fish. A faint color indicates borderline toxicity. The intensity of color is compared to a set of positive results ranging from 1 to 5. The average value for the scores from duplicate or triplicate sample strips is calculated and recorded for the corresponding laboratory report.

Applications

The Ciguatetect kit can be used for the detection of toxins associated with ciguatera fish poisoning and in rapid screening programs of toxic fish and shellfish in harvesting areas and the marketplace. In a kit configuration, this type of marine toxin detection assay can be used routinely for high-volume screening of suspect toxic fish on board ships, in rudimentary dockside laboratories and at aquaculture facilities, as well

as in regulatory agency laboratories.

Ciguatetect can be adapted to test mussel samples for the presence of the main toxin responsible for diarrhetic shellfish poisoning in some parts of the world. In addition to helping to monitor shellfish beds for shellfish poisoning toxins, the kit can be applied in shellfish depuration operations for elimination of the toxins, and to screen for toxic mussels, scallops and oysters in the marketplace.

Technologies such as this are useful to governments around the world concerned with rapid, inexpensive commercial testing procedures to identify unsafe fishing locations. They also help in random testing of suspect commercial catches to ensure the safest seafood products for the public.

This test kit is not yet available commercially. The LSU AgCenter continues to be involved in its development. ■

Acknowledgment

Ciguatetect is a registered trademark of HawaiiChemtect International, which helped to fund this research.

Consumers approve mandatory country-of-origin labeling of fresh or frozen beef

Louisiana first to require information

Alvin Schupp and Jeffrey Gillespie

Beef consumers are provided with various kinds of information on the fresh beef sold in grocery stores. Retail beef packages include all or some of the following: U.S. Department of Agriculture (USDA) Quality Grade, species of meat, standardized and common cut name, brand or store label, price per unit, weight, total package costs, refrigeration and cooking suggestions, packaging date and limited nutrient information. Shoppers use this information and visual observation to choose meats.

Restaurant patrons know much less about the beef served them. They must rely on the reputation of the restaurant and previous meals consumed in particular restaurants.

With limited exceptions, information on whether the beef was produced in the United States or imported has been unavailable to consumers. While U.S. Customs' regulations require all imported beef be labeled by country-of-origin on the bulk shipping container, the label is not required to accompany the beef to the next buyer unless imported in retail ready packages. Hence, all imported fresh or frozen beef essentially becomes U.S. beef when repackaged.

Louisiana has become the first state to mandate this labeling, however, when the 1999 Louisiana Legislature enacted legislation requiring all fresh meats sold in grocery stores beginning January 1, 2000, to indicate "American," "Imported" or "Blended," the latter consisting of a mix of U.S. and imported meat. The law exempted all food service use, including restaurants.

U.S. consumers may be interested in the country-of-origin of fresh or frozen beef for these reasons:

- Imported beef might differ in quality from U.S.-produced beef.
- Countries licensed to export beef to the United States differ in the degree of government control of use of specific chemicals in the production of the animals and their feeds.
- Consumers may be concerned with the stringency of regulation of slaughter and processing operations in the licensed countries.
- Some consumers prefer to purchase U.S. products over imported products.

The USDA states that all slaughter houses licensed to handle beef to be exported to the United States must meet the same requirements as those imposed on U.S. slaughter or processing plants. It also claims that all imported beef is randomly inspected at port of entry for residues or other adulterants. Now 32 countries, including Canada, Japan and Mexico, require all fresh beef to be labeled by country-of-origin at the retail meat counter.

To determine the preferences of Louisiana beef consumers concerning country-of-origin labels for fresh or frozen beef in grocery stores and restaurants, we sent a survey to 2,000 randomly selected households in eight parishes in the summer

of 1999. About 18 percent of the households responded to the survey. The sample was slightly biased toward higher income, more highly educated, white and older respondents, which is typical of the response rate from unsolicited mail surveys using bulk mail rates.

Respondents overwhelmingly considered U.S. beef superior to imported beef (86 percent rated U.S. beef superior to 14 percent rating U.S. and imported beef as equal). The primary reason for the superiority of U.S. beef was its higher quality. The remaining reasons involved consumer concerns about safety.

When asked whether they favored compulsory country-of-origin labeling of fresh or frozen beef, 93 percent favored the label in grocery stores and 88 percent in restaurants. Respondents who were more likely to favor the label for grocery stores were those who (1) favor domestic durable goods to imported durable goods, (2) rate U.S. beef superior to imported beef, (3) are black or (4) are from rural areas. Respondents who were less likely to be in favor of the label were (1) older, (2) single, (3) male, (4) engaged in farming or (4) had children in the household.

Respondents who were more likely to favor the label for restaurants were those who (1) favor domestic goods to imported durable goods, (2) rate U.S. beef superior to imported beef and (3) generally read nutrition labels on food items. Males were less likely to favor the label for restaurants.

Preference for the labels did not differ with income, education level, whether there was a homemaker in the household, and whether the respondent was retired. In most issues related to food consumption, these variables are important in explaining the household's choice.

The rate of approval of mandatory country-of-origin labeling of fresh or frozen beef in grocery stores and restaurants (averaging 91 percent) estimated from this study exceeds that of a recent national survey (76 percent).

The lower approval of mandatory country-of-origin labels for restaurant beef likely reflects the fact that consumers are more accustomed to having less information on the meats consumed in restaurants than is available on packaged meats in grocery stores.

The finding that households with single heads or households with children tend to be less supportive of the country-of-origin label needs to be examined by the domestic beef industry.

At this writing, implementation of the law is awaiting regulations that must be developed by the state Department of Agriculture and Forestry. ■

Alvin Schupp, Martin D. Woodin Professor, and Jeffrey Gillespie, Assistant Professor, Department of Agricultural Economics and Agribusiness, LSU Agricultural Center, Baton Rouge, La.

Ozone: New Weapon for Fighting Food Hazards

Joan M. King and Terry Walker

Ozone is a substance best known in two divergent ways. It is both beneficial—as in the ozone layer protecting the Earth from the sun's harmful ultraviolet rays—or detrimental when ground-level concentrations become excessive, particularly on hot, humid days.

Because ozone is one of the strongest oxidants known, it can be used to irreversibly degrade harmful microbes and toxic compounds. Ozone normally exists as a gas, which is more soluble in cold water than warm water. Ozone contains three atoms of oxygen whereas, in the air we breathe, oxygen contains only two atoms. Ozone is more reactive because of the extra oxygen atom and can donate an oxygen atom to other substances to oxidize them, leaving the remaining two oxygen atoms to form regular oxygen found in air. This fact is important because there is no residue left from the ozone itself.

Ozone can be produced commercially either through electrolysis or corona discharge. In corona discharge, air or pure oxygen is fed into a unit that converts the oxygen to ozone using high voltage. This procedure has disadvantages that include high capital and operating costs, generation of toxic molecules containing both nitrogen and oxygen if air is used, possible toxic contamination by the electrode material and, most important, low ozone concentrations of 2.5 to 7.5 weight percent.

The second method involves the use of water in an electrolytic cell. Oxygen in the water is converted to ozone by passage through positively charged and negatively charged surfaces. Concentrations of ozone in this method can exceed 20 weight percent. Municipal water can be used, and the reactants and products

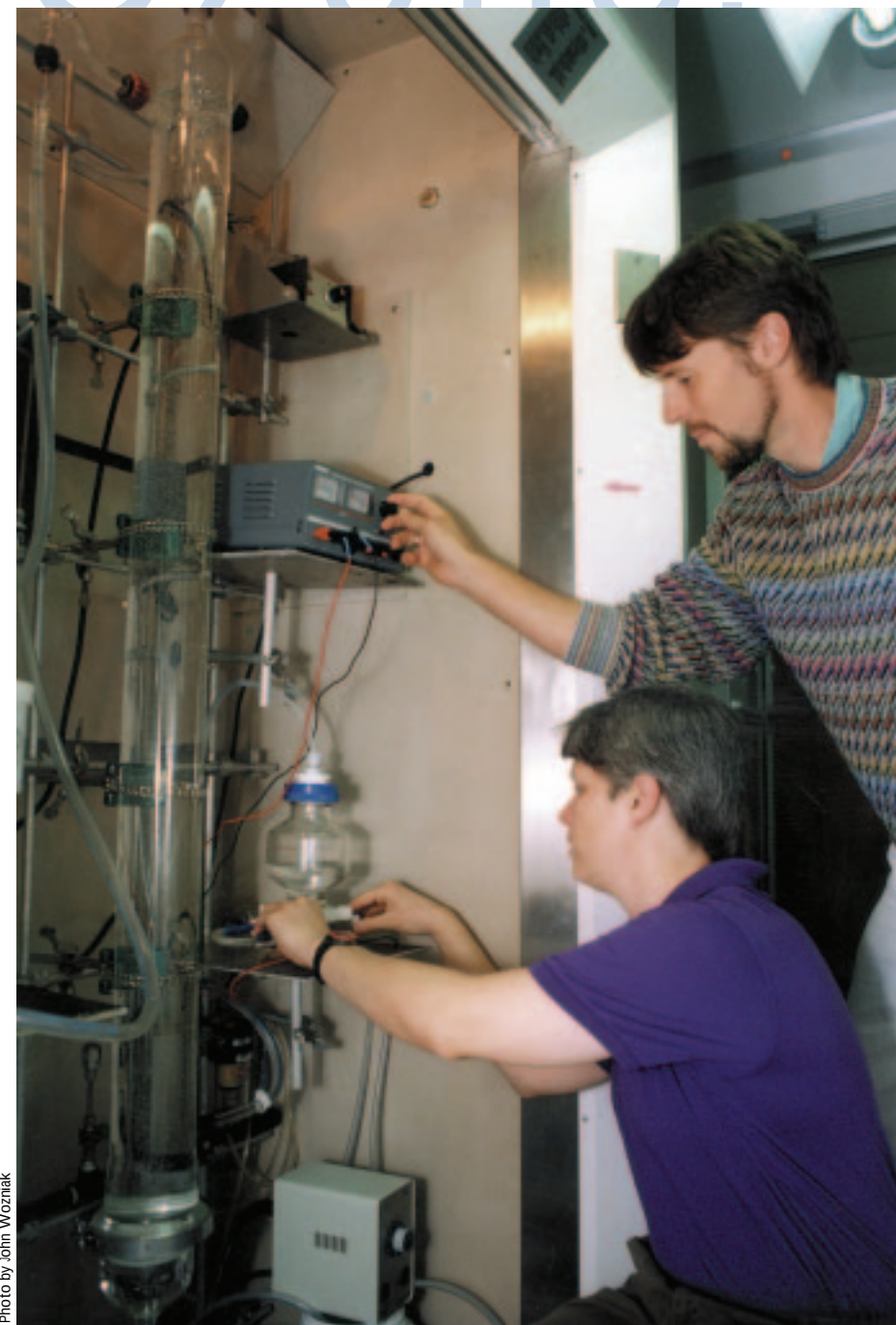


Photo by John Wozniak

Dr. Joan King, left, and Dr. Terry Walker are doing research on ozonation of food products as an alternative to other methods of eliminating pathogens. They are testing this ozonation processing unit as a way to remove off flavors from catfish.

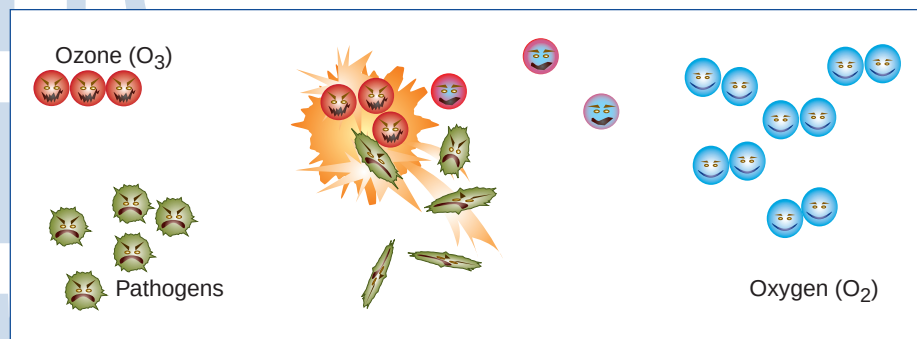
Joan M. King, Assistant Professor, Department of Food Science, and Terry Walker, Assistant Professor, Department of Biological and Agricultural Engineering, LSU Agricultural Center, Baton Rouge, La.

are safe. Only water and oxygen are left. This process is less costly than the corona discharge process because it uses less electricity and no special gases must be purchased. A commercial process for producing ozone with an electrolytic cell has been patented by Lynntech Inc. of College Station, Texas.

Although ozone has been produced artificially since the beginning of the 20th century and used in Europe for several decades, the Food and Drug Administration only recently approved (1997) ozonation for use in the U.S. food processing industry.

Ozone is becoming a widely used replacement for chlorine-based chemicals for water quality and for sanitation in food processing, especially in the meat industry. Studies have shown that ozone is a viable alternative to chlorine for bactericidal effects. For example, poultry carcasses chilled with water containing 3.0 to 4.5 parts per million ozone scored lower in microbial counts than those chilled in non-ozonated water. There was no significant color change or off flavor in the ozone-treated product compared with controls.

Recently, ozone has been used in aquaculture for control of bacteria, to disinfect and for water quality. Ozone generators are used in the United States, Russia and Japan to make ozonated processing water for cleaning fish. Ozonation has shown potential gains in



Ozone contains three atoms of oxygen unlike the oxygen in the air we breathe, which contains two. Ozone is highly reactive and can donate an oxygen atom to other substances, such as food pathogens, and oxidize them. This leaves the remaining two atoms to form oxygen, thus emitting no harmful residue.

catfish shelf life, ice quality production and more efficient operation of water chillers in fish processing plants.

At the LSU Agricultural Center, several studies have been initiated using ozonation. One involves degradation of off-flavor compounds in catfish fillets. Another is the decontamination of aflatoxin in corn grain samples. To help with these two research projects, an ozonation processing unit is being built in the Department of Biological and Agricultural Engineering in a joint project with the Department of Food Science. Figure 1 shows how this unit works. It involves the use of water in an electrolytic cell. A series of tubes and valves routes the generated ozone to the food product and to ozone detectors for

determining inlet and effluent ozone concentrations. For catfish fillets, the food will be in the treatment tank on a series of trays. Corn contaminated with aflatoxin will be ozonated in bins.

The unit built for contacting the food product such as catfish fillets and contaminated grains will be capable of treating the products with either gaseous or dissolved ozone. The materials used for construction must be resistant to highly corrosive ozone and are limited primarily to silica-glass, 316 stainless steel and Teflon. All ozone streams from the system will be collected in a thermal destruction unit containing a manganese dioxide catalyst that converts all residual ozone back to oxygen before being emitted to the atmosphere. ■

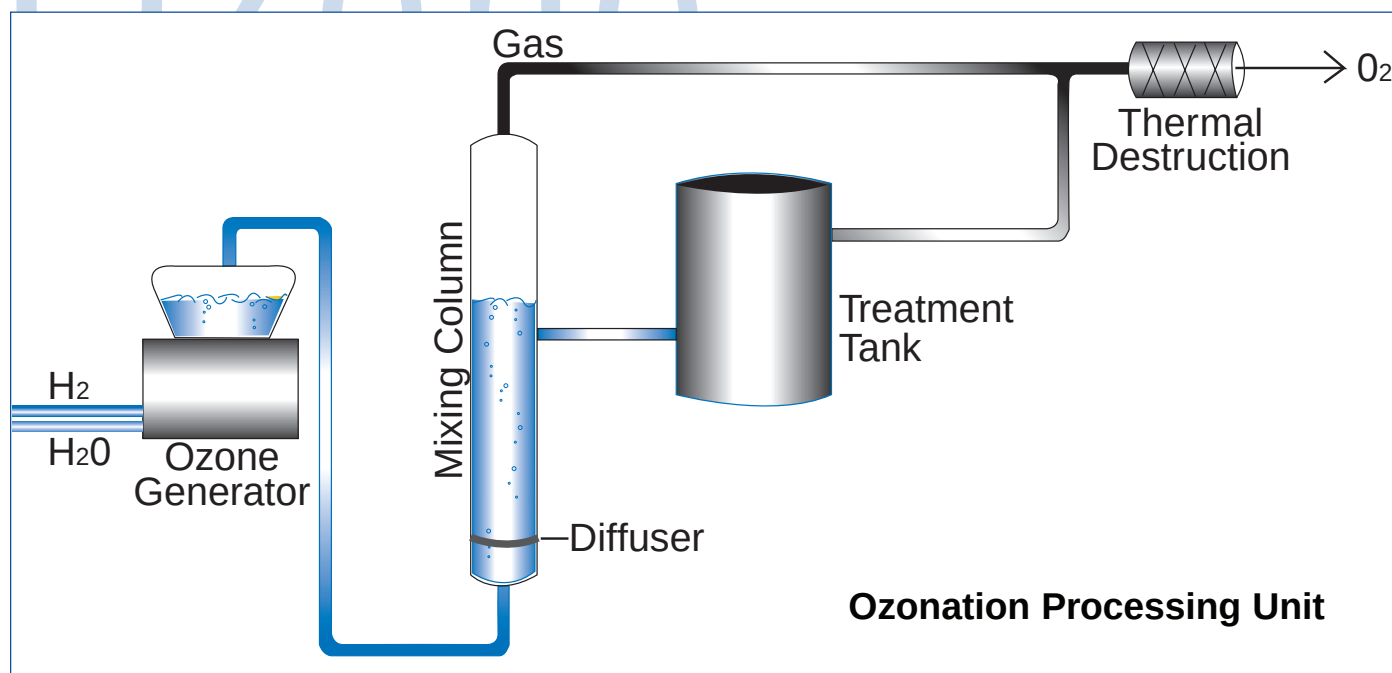


Figure 1. This is a diagram of the ozonation processing unit being tested at the LSU AgCenter. Hydrogen (H_2) and water (H_2O) go into the ozone generator which then sends the ozone through a mixing column of water to the treatment tank, where the food is placed. Any ozone left over from the ozonation of the food product will go through a thermal destruction unit and be emitted as oxygen.



Safety and Soft-Ripened, French-Style Cheeses

Jackin N. Nanua and John U. McGregor

Cheese is one of the most ancient forms of manufactured food. It is the product of enzymatic action and lactic fermentation of milk using various bacterial cultures. These enzymatic actions and fermentations lead to the coagulation of milk and production of typical cheese characteristics.

Fermented milk products originated in the Near East and then spread to southern and eastern Europe. Nomadic tribes who carried milk in storage pouches made from the stomachs of cows, sheep, camels or goats accidentally developed the earliest forms of cheese. Under warm storage conditions, the milk coagulated or clabbered because of the action of proteolytic enzymes naturally present in the storage containers and the production of acid end products by lactic bacteria. Fortunately, the predominant bacteria were lactic types (acid producers) and, therefore, helped to preserve the product by suppressing spoilage and pathogenic bacteria. People evidently enjoyed the refreshing, tart taste of this discovery and began to handle milk so that this preserving action would be encouraged.

Milk and curdled milk products are mentioned throughout history dating back as far as 4000 BC: "He asked for water, and she gave him milk; in a bowl fit for nobles she brought him curdled milk" (Old Testament, Judges 5:25). There is also remarkable pictorial evidence that the custom of keeping milk in containers for later consumption was already a craft systematically practiced by the Sumerians around 2900 BC. Through scientific principles and advances in manufacturing technology, these early products have developed into a highly diversified group of foods popular throughout the world.

The FDA recommends that pregnant women and immune-compromised people avoid consumption of soft cheeses such as Camembert, Brie, Roquefort, feta and Mexican-style cheeses because of the risk of listeriosis.

Different varieties of cheese are created by varying coagulation agents, processing methods and ripening agents. Cheeses can be classified by moisture content as hard, semi-hard and soft. During the ripening of cheese, lactic acid bacteria use lactose to produce acid and other flavor compounds, some of which inhibit undesirable contaminating microorganisms.

Mold-ripened soft cheeses such as

"Cheese is probably the best of all foods, as wine is the best of all beverages."

Patience Gray, author

Camembert and Brie are inoculated with the mold *Penicillium camemberti*, which produce proteolytic enzymes leading to protein hydrolysis. The amines and ammonia produced during protein hydrolysis raise the pH of the cheese to levels that can allow growth of undesirable microorganisms. Spices are sometimes added to these cheeses, and these could introduce undesirable microorganisms into the cheese. It has been demonstrated that pathogens such as *Listeria monocytogenes* can grow during the ripening of Camembert cheese but decrease during the ripening of Cheddar cheese.

Disease risk

A number of disease outbreaks have been traced to consumption of soft cheese. This has raised safety concerns, especially for vulnerable consumers such as pregnant women and immune-compromised individuals. The Food and Drug Administration (FDA) recommends that pregnant women avoid consumption of soft cheeses such as Camembert, Brie, Roquefort, feta and Mexican-style cheeses because of the risk of listeriosis. Stringent hygienic standards should be maintained during the manufacture and subsequent handling of soft-ripened cheese to minimize chances of contamination.

Researchers in the LSU Agricultural Center's Department of Dairy Science conducted a study to assess the microbiological quality of imported and

domestic soft-ripened, French-style cheese in the retail market. Cheese samples—three imported French Brie varieties, one German Camembert variety and one U.S. Camembert—were collected from three supermarkets located in the greater Baton Rouge area. Samples were analyzed in the Dairy Science Department. The cheeses were aseptically sliced to obtain surface, intermediate and center samples.

Analyses were performed immediately. Age of the cheese could not be determined, but they were within the "sell by" date. The sampling was replicated three times.

The pH and proteolysis decreased from the surface to the center. This could be attributed to the activity of the ripening molds. Molds produce proteases and other enzymes that break down proteins leading to the formation of amino acids, peptides and ammonia. They also degrade lactic acid, milk fat and produce carbon dioxide. Protein breakdown causes an increase in soluble citrate and short-chain peptides. The net effect is an increase of pH. The average moisture content was 43 percent for Brie and 48 percent for Camembert. The high pH and moisture contents observed in these cheeses could encourage the growth of microorganisms including pathogens. Many common pathogens grow within a pH range of 4.5 to 10. Surface mold-ripened cheeses with a pH of about 6 can support the growth of pathogens. *Listeria monocytogenes*, *Enterobacter aerogenes* and *Escherichia coli* have been reported to grow in Camembert cheese. *L. monocytogenes* grow at pH 5.5 to 5.3.

Plain Brie and Brie with herbs had higher coliform counts than U.S. Camembert and Brie with peppercorns (Table 1). In addition, Brie with herbs

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Table 1. Mean Coliform Count

	Brie-pep	Cam-Germ	Cam-USA	Brie-plain	Brie-herb	Mean
Surface	0.69	4.53	1.46	3.13	5.47	2.95
Intermediate	0.00	0.00	0.00	1.13	3.83	1.06
Center	0.60	0.00	0.00	0.93	2.55	0.87

Brie-pep = Brie with peppercorns; Brie-plain = plain Brie; Brie-herb = Brie with herbs; Cam-Germ = Camembert from Germany; Cam-USA = Camembert from USA.

had high coliforms in the interior while all the other cheeses had very few coliform counts in their interiors. The higher internal contamination of Brie with herbs might be caused by mixing herbs into the cheese. The herbs are mixed into the cheese interior, and peppercorns are applied only to the surface.

Brie and Camembert

Brie had a higher incidence of microbiological contamination than Camembert. Brie is typically sliced into wedges in the retail shop, and

Camembert is presented as whole wheels. Contamination may have occurred during the cutting in the supermarkets. Four Brie wheels were collected from the supermarkets before cutting into wedges and analyzed for coliforms to determine whether contamination was at the cutting stage. Only one wheel had detectable coliform bacteria, confirming that cutting in the supermarket is probably responsible for most of the contamination with coliforms. No *E. coli* were detected in any of the cheese samples examined. Canned Camembert, which is normally pasteurized by

dipping in hot water, had no viable microorganisms.

The soft-ripened cheeses examined in this study had viable coliforms. This indicates conditions that could have exposed the products to microbial contamination. This is a cause of concern, especially for high-risk consumers such as pregnant women, the young, the elderly and immune-compromised individuals. High-risk consumers should consume cheeses like Cheddar and mozzarella instead.

The higher coliform count on the surface suggests post-process contamination, most likely during cutting and the adding of spices for Brie. This could be reduced by using high quality spices and by following good sanitary procedures during the cutting step carried out at retail supermarkets.

Another means for potentially improving the microbiological quality of cheese at the retail level is to buy cheese cut and wrapped at the cheese manufacturing plant. The sanitary procedures used in dairy processing plants are typically strict and carried out by highly trained food industry professionals. ■

Two studies look at packaging of ground beef

Pathogenic microorganism hazards with reduced oxygen packaging of ground beef

Although most refrigerated, uncooked beef is still packaged in traditional air-permeable, moisture-impermeable film on a polyfoam tray, more ground beef is being packaged at a central facility with different proportions of atmospheric gases (nitrogen, carbon dioxide, oxygen) to inhibit the growth of spoilage and pathogenic (disease-causing) microorganisms.

Since spoilage bacteria usually grow faster than pathogens, consumers have been able to use the spoilage indicators of odor and discoloration to determine the relative safety of refrigerated foods. However, several studies have indicated that pathogenic microorganisms may outgrow the spoilage organisms in atmospheres with little or no oxygen. This hazard may be greater if elevated temperatures occur during storage or retail display.

For this experiment, ground beef patties were packaged in two reduced oxygen types to determine the relative growth rates and types of microorganisms during refrigerated storage and display. Patties weighing 1/4 pound were formed from ground chuck and assigned to two packaging treatments: vacuum or modified atmosphere (MAP) containing 50 percent nitrogen and 50 percent carbon dioxide.

After 15 days of storage at 30 degrees F, the gas atmospheres in the MAP packages were exchanged for 80 percent oxygen and 20 percent carbon dioxide. The patties were removed from vacuum packaging and were overwrapped in polyvinylchloride film. Packages were displayed three days at 45 degrees or 60 degrees F under simulated retail conditions.

Samples were taken at zero, 8, 15, 16, 17 and 18 days after initial packaging to determine color, microbial numbers and types of microorganisms.

There was no difference in microbial numbers on patties in MAP or vacuum packaging for patties during the first 8 days of the initial storage period. However, the microbiological counts on patties stored in vacuum increased greatly from days 8 to 15. This was unexpected since a storage temperature of 30 degrees F close to the freezing point (28 degrees F) of beef usually inhibits microorganism growth, as was observed with the patties in MAP.

Microbiological growth increased upon retail display with both temperatures. The 45 degrees F temperature is not uncommon for meat display cases, although 41 degrees F or below is recommended.

Retail display of patties at the abusive temperature of 60 degrees F caused rapid growth of microorganisms in both types of packaging compared with display at 45 degrees F. The numbers of pathogenic bacterial species increased from 11 percent to 70 percent in MAP and from 24 percent to 50 percent in overwrapped packages displayed at 60 degrees F during the three days of display.

Discoloration of the bright red beef pigments to brown is often used as an indication of the advancing spoilage of ground beef. Patties in MAP with high levels of oxygen were darker and redder than patties stored in vacuum. Patties in MAP were redder than patties in air-permeable packaging through the first two days of retail display because of the higher levels of oxygen in the

packages. The lightness of patties in MAP remained fairly constant through three days of retail display. Display at 60 degrees F decreased lightness of patties in air-permeable packages and decreased redness of patties in MAP compared with display at 45 degrees F.

The implications from this research are that reduced oxygen atmospheres will alter the microbial populations, while exerting minimal influences on color during storage and retail display. The increased percentage of pathogenic microorganisms with retail display in oxygenated conditions was increased even more with abusive temperatures during display. Processors and retailers should be vigilant in maintaining low temperatures in display cases to safeguard their refrigerated meat products for consumers.

Influence of display gas mixture on shelf life of ground beef in modified atmosphere packaging

Modified atmosphere packaging (MAP) of fresh meat products can improve the shelf life, reduce economic loss and improve product quality. The use of vacuum to remove oxygen prevents oxidative changes, but also causes meat to become a purple color, which is unappealing to consumers. Inclusion of carbon dioxide in MAP will inhibit microorganism growth and increase shelf life.

Ground beef is the major fresh beef product, accounting for about half of the total beef consumed in the United States. To determine the levels of gases for optimal display shelf life of ground beef, different gas atmospheres during storage were exchanged with different gases before retail display.

Ground beef patties were manufactured from chuck rolls by grinding muscles through 1/2-inch and 1/8-inch plates before forming into 1/4-pound square shapes on a mechanical former. Patties were assigned to packaging in vacuum or one of three types of modified atmosphere packaging (MAP): 80 percent nitrogen and 20 percent carbon dioxide, 50 percent nitrogen and 50 percent carbon dioxide or 20 percent nitrogen and 80 percent carbon dioxide for storage in the dark at 30 degrees F.

After 15 days, the vacuum patties were removed, placed onto polyfoam trays and overwrapped with air-permeable, moisture-impermeable polyvinylchloride film. The atmospheres in the MAP packages were exchanged for 80 percent oxygen and 20 percent carbon dioxide; 50 percent oxygen, 20 percent carbon dioxide and 30 percent nitrogen; or 20 percent oxygen, 20 percent carbon dioxide and 60 percent nitrogen. All packages were displayed under simulated retail conditions of 45 degrees F.

The storage gas mixtures of nitrogen and carbon dioxide had a large influence on the growth of psychrotrophic microorganism plate counts on patties in MAP during storage and retail display. The display gases of oxygen and carbon dioxide had little influence on microorganism growth during display. The psychrotrophic bacteria are those able to tolerate and grow in refrigerated temperatures. Many of the pathogenic microorganisms that cause foodborne disease are psychrotrophs. Increased levels of carbon dioxide inhibited psychrotrophic microorganisms until the atmospheres were exchanged for oxygen and carbon dioxide on day 15. Then the carbon dioxide in the gas mixtures was unable to impede the growth stimulated by oxygen. The vacuum atmosphere did not inhibit bacterial growth during the storage period.

Color of fresh refrigerated meat is the main criteria used by consumers to make their purchase decisions. The values that indicate lightness of color were not different among patties from the different storage or display packaging treatments. The redness of patties during storage was similar between vacuum and MAP treatments. After gas exchange for oxygen mixtures, the color of beef patties in MAP became redder. The patties from vacuum storage treatment that were exposed to air became redder (bloomed) slightly, but less than the patties in oxygen. The red color faded after 2 days of display under lighted retail conditions and was not acceptable for consumer purchase after 4 days of retail display. Patties in higher levels of oxygen had higher yellow values than patties in lower levels of oxygen during display. Following re-packaging in air-permeable film, patties stored in vacuum were less blue during the dark storage and had yellow values similar to the patties in 50 percent oxygen, 20 percent carbon dioxide and 30 percent nitrogen.

Oxygen is a concern with refrigerated packaged fresh meat because it causes oxidation of the lipids and rancidity to develop. In this study, lipid oxidation increased during storage in vacuum or in nitrogen/carbon dioxide gases. The lipid rancidity increased greatly during exposure to light during retail display and was higher with increased levels of oxygen in the display gas mixtures.

This study investigated the use of different gas mixtures on the shelf life of ground beef patties during storage and retail display. Increased levels of carbon dioxide inhibited the growth of psychrotrophic microorganisms while increased levels of oxygen increased red color and lipid oxidation. The most desirable gas combinations for MAP of ground beef in this study appeared to be 50 percent nitrogen and 50 percent carbon dioxide exchanged for 50 percent oxygen, 20 percent carbon dioxide and 30 percent nitrogen for retail display. This MAP gas system resulted in ground beef patties that had low microbial growth during storage and minimum lipid rancidity and desirable red bloomed color during display compared to other treatment combinations. ■

Chung Ping Ho, Image Global Marketing Development and Services Company, Taipei, Taiwan, former graduate student; Kenneth W. McMillin, Professor, Department of Animal Science, LSU Agricultural Center, Baton Rouge, La.; and Nai Yun Huang, U.S. Meat Export Federation, Taipei, Taiwan, former graduate student.

Inhibition of *E. coli* in Ground Beef Patties with Ozone

Recent illnesses and deaths traced to foods contaminated with *Escherichia coli* (*E. coli*) O157:H7 have caused processors, regulatory officials and scientists to examine different techniques to control and destroy pathogenic microorganisms. The pathogenic microorganisms in meat products may survive or grow during refrigerated storage. Foodborne illness can occur when precooked or raw meat products are eaten without adequate heating to destroy pathogens.

Irradiation has recently been approved to treat meat products and kill pathogenic bacteria. Though effective, this preservation method may be expensive and alter the palatability and shelf-life properties of meat products.

Another preservation technique being investigated involves ozone, which may be equally effective in destroying pathogenic microorganisms with less cost and fewer product changes. This study was conducted to determine the effect of gaseous ozone on spoilage and pathogenic microorganisms in ground beef.

Ground beef was treated in two ways: (1) coarsely ground and vacuum packaged or (2) finely ground (1/8-inch) and formed into 1/4-pound patties. The patties were packaged in modified atmospheres (MAP) in three ways: (1) 80 percent oxygen and 20 percent carbon dioxide (O); (2) 80 percent nitrogen and 20 percent carbon dioxide (N) or (3) 2.5 percent oxygen, 20 percent carbon dioxide and 77.5 percent nitrogen ozonated with 2,500 parts per million of ozone (O₃).

All ground beef was stored in the dark at 36 degrees F.

After 10 days, the coarse-ground, vacuum-packaged beef was finely ground, made into 1/4-pound patties and placed on foamed polystyrene trays overwrapped with air-permeable film, and the MAP packages for N and O₃ treatments had the gaseous environments exchanged for O.

All packages were then displayed under cool white fluorescent light at 45 degrees F for 4 days.

Results included:

- The color of the ground beef patties was similar among treatments during storage and display.

- Rancidity was higher in ground beef patties in oxygen compared with the other treatments during storage. Upon repackaging or gas exchange, there was more rancidity. After 2 days of retail display, the rancidity level was very high, indicating that the product taste would probably be unacceptable to consumers.

- Microorganism counts were higher in coarsely ground beef stored in vacuum packages and remained higher through the display of patties in air-permeable, overwrapped packages compared with the other packaging treatments. The carbon dioxide in the other packaging treatments was probably responsible for inhibiting the growth of microorganisms on the beef patties. Ozone was not effective in inhibiting the general microbial species associated with ground beef.

- The level of coliforms increased in the coarsely ground beef in the vacuum package during storage, but remained stable in the other packaging treatments until display. Coliforms are the species of microorganisms, including *E. coli*, that indicate unsanitary conditions and potential foodborne illness hazards. The high levels of oxygen in these packages appeared to destroy coliform organisms during the first 2 days of retail display. Coliform counts in ground beef patties in the oxygen and ozone treatments decreased in the last days of storage and throughout the display time.

Different packaging environments and treatments will influence the properties of ground beef during storage and retail display. Gas atmospheres that provide longer shelf life during storage give a purple meat color that is not acceptable for retail display. Packaging that



Photo by John Wozniak

LSU AgCenter scientists are testing the use of ozone gas to kill bacteria in packaged ground beef. Behind Michael Michel, research associate in Animal Science, is a gray box, which is the ozone generator.

provides contact of oxygen with the meat surface blooms the ground beef to a desired red color, but the color fades and lipid oxidation occurs within 2 to 3 days after display. Oxygen and ozone appeared equally effective in destroying coliforms in the ground beef. Studies are continuing on the effects of ozone on *E. coli*. ■

Brian S. Smith, former graduate student and now with Central Soya Company, Fort Wayne, Ind.; Kenneth W. McMillin, Professor; Thomas D. Bidner, Professor, Department of Animal Science, LSU Agricultural Center, Baton Rouge, La.; and Arthur M. Spanier, U.S. Department of Agriculture Agricultural Research Service, Beltsville Animal Research Center, Beltsville, Md.



Photo by John Wozniak

Dr. Ken McMillin, professor in Animal Science, heads the research on ozonation of meat as a way to preserve it. The patty on the right has been treated with gaseous ozone and is a slightly lighter red than the patty on the left.

Safety and Properties of Precooked Pork Roasts with Sodium Lactate and Sodium Tripolyphosphate

Consumers continue to demand more convenience with food products, including meat. Safety is a primary concern with precooked, ready-to-eat meat products. Meat processors strive to develop processed meat items to meet consumer demand and increase meat consumption.

Many different food additives are available to enhance flavor, inhibit microorganisms and preserve quality in meat. One such additive not in general use is sodium lactate, which is a neutral salt of lactic acid. An advantage of this additive is that it is perceived as "natural" or "organic" by some advocacy groups, as opposed to an artificially produced additive. Sodium lactate has been shown to extend shelf life and enhance flavor without altering other product characteristics.

Few uncured, precooked pork items are available for consumers. To test the value of sodium lactate as an additive in manufacturing precooked pork roasts, which would be an additional meat item for the marketplace, a study was done that compared sodium lactate and sodium tripolyphosphate, used alone and in combination. Sodium tripolyphosphate, a common additive, is used in meat products to increase juiciness and texture.

Sodium lactate and sodium tripolyphosphate were incorporated into boneless fresh pork leg muscles. The muscles were netted to form 6- to 8-pound roasts cooked to 155 degrees F internal temperature in a smokehouse. Roasts were chilled to 40 degrees F and sliced into 1/4-inch sections that were vacuum packaged. Packages were stored at 40 degrees F for sampling at zero, 4, 6 and 8 weeks.

Roasts containing sodium tripolyphosphate had higher cooking yields (83 percent) compared with 69 percent yield of roasts with no phosphates. The cooked roasts containing phosphates retained more moisture (70 percent) than roasts

without phosphates (67 percent). Fat and protein content were lower in roasts containing phosphates (3.4 percent fat, 24.2 percent protein) than in roasts without phosphates (3.9 percent fat, 26.4 percent protein).

Tensile strength necessary to shear the slices was higher in roasts containing phosphates. Roasts with phosphates were also lighter, redder and bluer, and thus more appealing, than roasts without phosphates. Sodium lactate did not change texture, lightness and redness, but increased levels caused slightly bluer hues on slice surfaces.

Sensory scores increased for salt flavor and off-flavor and decreased for pork flavor with increased levels of sodium lactate. The use of phosphates decreased oxidative rancidity during the 8 weeks of refrigerated storage but did not affect growth of microorganisms during refrigerated storage. Higher levels of sodium lactate inhibited psychrotrophic microorganisms in the precooked pork more than lower levels of sodium lactate through 4 weeks of storage at 40 degrees F. The psychrotrophic microorganisms are of food safety concern because they will grow and may produce toxins at refrigerated temperatures.

This study helped add information about use of sodium lactate as a food additive for pre-cooked meat products. The proper combination of additives, including sodium lactate and sodium tripolyphosphate, can improve product safety and palatability while minimizing product changes during storage. ■

Dean J. Antie, Manda Fine Meats, former graduate student; Kenneth W. McMillin, Professor, Department of Animal Science; J. Samuel Godber, Professor, Department of Food Science, LSU Agricultural Center, Baton Rouge, La.; and Douglas L. Marshall, Associate Professor, Department of Food Science and Technology, Mississippi State University, Starkville, Miss.

Managing Aflatoxin Contamination in Corn

Scientists Use Integrated Approach to Solution

**Joan M. King, Terry Walker, Henry Njapau,
Douglas L. Park and Kenneth E. Damann Jr.**

Aflatoxin is a natural toxin produced by the fungus *Aspergillus flavus*. Aflatoxin in corn appears when high temperatures and drought stress occur, which favors infection of the ear by the fungus. Southern states are more likely to have this problem than are the cooler mid-western and northern Corn Belt areas. Louisiana experienced particularly severe aflatoxin contamination during the 1998 growing season. This resulted in a large financial loss to Louisiana farmers who had to either destroy their crops or sell them at a significantly

reduced price. If a viable alternative had existed for treating the infected grain to eliminate the aflatoxin, the farmers could have received a larger return for their investment.

The possible contamination of food crops by aflatoxins and their potential toxicity to people and livestock have been known for almost 40 years. Aflatoxin is known to cause liver damage and cancer in animals and humans.

Worldwide, numerous studies aimed at understanding the biology of the fungi

Joan M. King, Assistant Professor, Department of Food Science; Terry Walker, Assistant Professor, Department of Biological and Agricultural Engineering; Henry Njapau, Research Associate, Audubon Sugar Institute; Douglas L. Park, former Professor and Head, Department of Food Science and now with the U.S. Food and Drug Administration; and Kenneth E. Damann Jr., Department of Plant Pathology and Crop Physiology, LSU Agricultural Center, Baton Rouge, La.



Photo by Mark Claessens

The LSU AgCenter's Northeast Research Station in Winnsboro was set up as an aflatoxin testing station in 1998 for farmers in that area to have their corn tested. Allen Brown, former research associate, was involved in the testing.

that produce aflatoxins and the elimination of the toxins have been carried out. Indeed, the understanding of events leading to the formation of aflatoxins in food crops and the effects on consumers has increased tremendously.

Preventing contamination is the best method for managing the risk associated with consuming aflatoxin-contaminated foods. If contamination occurs, however, the hazards associated with the toxin must be managed through post-harvest procedures. Research has focused on both pre-harvest prevention and post-harvest removal of aflatoxins from grains. The continuing challenge of aflatoxin prevention necessitates the need for improved post-harvest techniques to detoxify valuable grain supplies that would otherwise end up as hazardous waste material.

Aflatoxin decontamination can be done physically, biologically and chemically. Physical methods such as separation of contaminated grain by density in water, screening or milling result in loss of product and do not completely remove all contaminated portions. Other physical methods such as heating or irradiation are either cost-prohibitive or non-effective for dry samples. Biological methods, which include development of transgenic crops resistant to the mold or use of microorganisms that destroy the mold, are relatively harmless to the crop and show some potential, but they have yet to be completely effective in decontamination.

A number of chemical methods have been successfully implemented for

deactivation of aflatoxins in grains. Treatment with chemicals such as ammonia, methylamine and sodium hydroxide in the presence of moisture and heat have shown potential, but reduced protein nutritional availability was observed in rat feeding tests. Chemical inactivation by ammoniation has wide-spread use and acceptance, but the cost is approximately \$20 per ton.

Ozonation is a chemical method that shows potential for decontamination of grains containing aflatoxin. Ozone is becoming a widely used replacement for chlorine-based chemicals for sanitation purposes in food processing, especially in the meat industry and for water quality purposes, such as bacterial, odor, pesticide and hazardous compound degradation. Compared to ammoniation treatment, decontamination with ozonation is estimated to cost only about \$4 per ton.

One area of research in the Food Science and Biological and Agricultural Engineering departments is focused on the suitability and safety of the ozonation procedure for decontaminating aflatoxin-contaminated corn. The ultimate goal is not only 100 percent detoxification of aflatoxin-contaminated corn, but ensuring the product is safe for consumption by animals.

Other research at the LSU Agricultural Center includes the following:

A breeding approach to production of resistant corn hybrids. This is a joint project in the Agronomy Department and with the Dean Lee Research Station.

In the Entomology Department,

scientists are developing control practices to limit insect damage, thereby closing off a potential avenue of entry and spread into the ear by the fungus.

At the Northeast Research Station, scientists are assessing management practices, such as irrigation and fertilization, which minimize stress.

In a joint project between the Northeast Research Station and the Plant Pathology Department, researchers are evaluating about 75 commercial corn hybrids each year for aflatoxin contamination in an inoculated test. This provides information for growers on hybrids to select to minimize exposure to aflatoxin contamination.

LSU AgCenter scientists also are exploring novel approaches to the aflatoxin problem, including chemical treatment to turn on corn disease resistance genes leading to systemic acquired resistance. A second approach uses the herbicide Liberty on inoculated LibertyLink and non-LibertyLink corn to produce ammonia through its interaction with the fungus and the plant. Ammonia is toxic to the fungus and also directly degrades the aflatoxin molecule. Preliminary results appear promising. A third biological control approach applies a microorganism to the corn ear that is inhibitory to the fungus in culture.

No single method will ensure the complete removal of aflatoxin. A multidisciplinary effort can significantly reduce the risk associated with aflatoxin contamination and yield products safe and acceptable to the consumer, yet cost-effective for producers. ■

Learn to Keep Food Safe

LSU AgCenter Extension conducts "Safe Food Handlers" workshops to help people learn to keep food safe. Notable among the participants are the food vendors for the New Orleans Jazz and Heritage Festival. This organization requires that all vendors who sell food at this annual event complete this 8-hour training course.

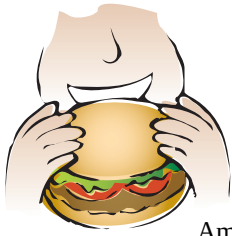
A spin-off of this training program is called "Safe Food, Healthy Children." In this program, extension specialists teach food handlers from day care centers, preschools and Head Start centers. Part of this training involves teaching young children about food safety with a "Hurray for Hand Washing" curriculum.

Food safety extension publications available to the public include the following. One copy is free to any Louisiana

resident. You may obtain them from your local parish extension office or order from the Internet at <http://www.agctr.lsu.edu/wwwac/puborder.htm>.

- There's a Fungus Among Us! Food Molds—An Important Health Concern #2488
- Fight Bac #2700
- Handling Food and Water After a Storm or Flood #2527I
- How to Cook When the Power Goes Off #2527L
- Play It Safe with Food After a Power Outage #2527M

Foodborne Illness: Are You at Risk?



Although Americans enjoy the safest food supply in the world, several recent outbreaks of foodborne illness have heightened concern about food safety.

In the United States, between 6.5 million and 81 million cases of foodborne illness and as many as 9,100 related deaths are reported annually. In addition, the risk of incurring foodborne illness is increasing because of more large-scale production and distribution techniques that allow contaminated products to reach more individuals. The number of people in high risk groups such as those with suppressed immune systems and the elderly is increasing also. Children are more at risk because more of them spend significant amounts of time in group settings.

In addition, bacteria have found new modes of transmission. Some are more resistant to long-standing food processing and storage techniques. Virulent strains of well-known bacteria have emerged. The exact cost of foodborne illnesses is unknown, but estimates of the cost of medical treatment and lost productivity may be as much as \$5 billion to more than \$22 billion annually.

Contamination Sources

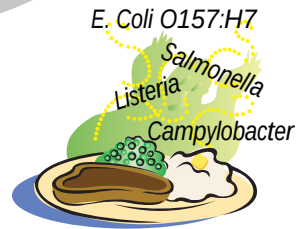
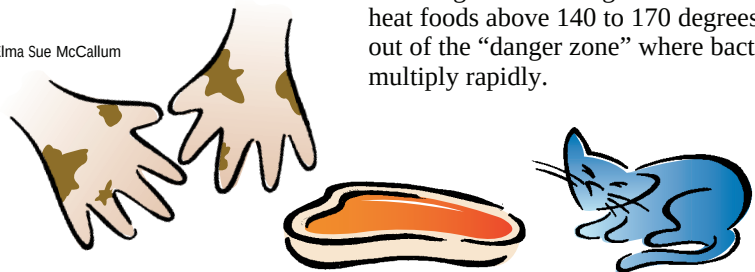
Although more than 30 pathogens are associated with foodborne illness, the Centers for Disease Control (CDC) considers *E. Coli* O157:H7, *Salmonella* Enteritidis, *Listeria monocytogenes* and *Campylobacter jejuni* the most impor-

Evelina Cross and Maren Hegsted

tant. The most common carriers are foods of animal origin such as beef, pork, poultry, eggs and seafood products. But many other foods, including milk, cheese, ice cream, orange and apple juices, cantaloupes and vegetables, have been involved in outbreaks during the last decade. The sources of contamination of food by the four pathogens identified by the CDC are in Table 1.

Although foodborne illnesses are of short duration and do not require medical treatment, serious complications and death can result. *E. Coli* O157:H7 can cause kidney failure in young children and infants. *Salmonella* can lead to reactive arthritis, serious infections and deaths. *Listeria* can result in meningitis and stillbirths, and *Campylobacter* can cause arthritis, blood poisoning and be a precipitating factor for Guillain-Barre syndrome.

Illustrations by Elma Sue McCallum



Prevention

According to the CDC, 97 percent of foodborne illness can be prevented by improved food handling practices such as proper cooking and storage of food and appropriate personal hygiene practices by food handlers. Since bacteria are found naturally all around us, safe handling is necessary to prevent the bacteria from multiplying and causing foodborne illnesses.

One of the most important factors in controlling bacterial growth is temperature. Most foodborne outbreaks in the United States are the result of improper temperature control. Heating food to a specified temperature and maintaining that heat for a given time, depending on the food, will destroy most microorganisms. The general rule is to heat foods above 140 to 170 degrees F or out of the "danger zone" where bacteria multiply rapidly.

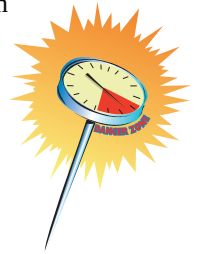
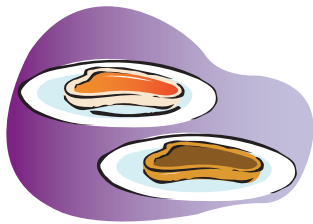


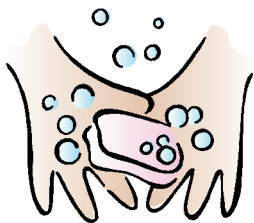
Table 1. Sources of Food Contamination

PATHOGEN	SOURCES	FOODS
<i>E. coli</i> 157:H7	Animal and human feces, untreated water	Raw or undercooked ground beef, unpasteurized milk, produce
<i>Salmonella</i>	Raw meat and poultry, human and animal feces	Eggs, poultry products, meat, dairy products, seafood, fruits, vegetables
<i>Listeria</i>	Soil, plants, water, animal feces, refrigeration condensate	Soft cheese, other dairy products, raw produce, deli items, meat, seafood, fruits and vegetables
<i>Campylobacter</i>	Animals, flies, raw poultry	Poultry, unpasteurized milk, raw vegetables, meat

Evelina Cross, Professor and Interim Director, and Maren Hegsted, Professor, School of Human Ecology, LSU Agricultural Center, Baton Rouge, La.



Avoiding cross contamination of foods also is essential to safe food handling. To prevent cross contamination, all hands, utensils and surfaces touching raw food should be thoroughly washed and sanitized before being used again for either raw or cooked food. This includes tabletops, cutting boards, knives, forks and slicers as well as aprons, cleaning cloths and sponges.



Personal Hygiene

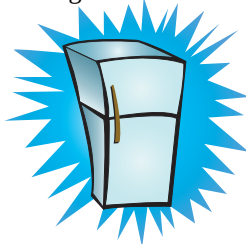
The personal hygiene practices of food handlers are critical to preventing foodborne illness. Hands should be washed frequently, especially before handling food, after touching raw meat or eggs, after using the restroom, sneezing or handling garbage.



When shopping for food, consumers are advised to notice the “sell by” and “use by” dates to be sure they have not expired. The “use by” date applies to use at home. Both labels refer to the quality of the food and are not a guarantee of an uncontaminated product. Examine the packaging of the items, and do not select those with holes or tears. Cold food items should be kept cold, and frozen foods frozen solid. When possible, place raw poultry, meat or fish in separate plastic bags to ensure that they do not leak and contaminate other unprotected foods. Plan to select perishable food items, especially meats, just before leaving the store to reduce the time the food is at room temperature. If groceries must be left in the car for longer than 30 minutes, use a cooler to transport perishables home.

Upon arriving at home, place perishable foods immediately in the refrigerator or freezer. Be sure the

refrigerator temperature is at 35 to 40 degrees F. Store uncooked meat, fish and poultry products on a plate on the lowest shelf of the refrigerator so raw juices do not drip on other foods and contaminate them. Always defrost meat, poultry or fish in the refrigerator or under cold

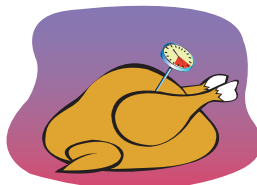


running water because bacteria multiply rapidly at temperatures between 40 to 140 degrees F.

Keep Clean

Keep everything that touches food clean. Wash hands with hot, soapy water before preparing any food and after handling raw meat, poultry and fish. Use separate platters, cutting boards, trays and utensils for cooked and uncooked meat, poultry and fish. Prevent juices from raw meat, poultry and fish from coming into contact with any other foods, either cooked or raw. Always wash contact surfaces and utensils with hot, soapy water immediately after preparing these products. Use separate cutting boards for each food type. Never use the same board for raw meat or poultry and then for cooked or ready-to-eat foods. Cutting surfaces can be sanitized by washing with a solution of two or three teaspoons of household bleach in one quart of hot water, then rinsing with plain, hot water. Direct sneezes and coughs away from food and preparation areas, and wash hands after sneezing or coughing. Wash all produce thoroughly with clean, drinkable water.

Cook ground meats thoroughly to an internal temperature of 160 degrees F or until the juices run clear. Ground poultry should be cooked to at least 165 degrees F. Cook beef to at least 145 degrees F, pork to 160 degrees F and poultry to 170 degrees F. Do not cook dressing in the cavity of the bird; instead, cook it separately. Do not partially cook food to finish later. A temperature high enough to destroy bacteria may not be reached with partial cooking and will allow bacteria to multiply rapidly.



Never leave cooked meat or other perishable foods at room temperature longer than two hours. Keep all cold foods at temperatures below 40 degrees F and hot foods at an internal temperature of at least 140 degrees F. Freeze or refrigerate leftover foods immediately. Cut large portions in smaller portions to speed cooling time, and, to speed cooling, use small, shallow containers. Always reheat leftovers to at least 165 degrees F. Sauces and gravies should be reheated to a rolling boil for at least one minute before serving.

Consistently following these rules for safe handling, preparing, storing and reusing foods will greatly reduce the risk of foodborne illness for you and your family. ■



When in doubt, throw it out!

For more information about food safety, contact:

USDA Meat and Poultry Hotline

Monday through Friday,
9 a.m. to 3 p.m. central time
(800) 535-4555

Centers for Disease Control and Prevention

Foodborne Illness Line
24-hour recorded information
(404) 332-4597

National Cattlemen's Beef Association

www.beef.org

USDA Food Safety and Inspection Service

<http://www.fsis.usda.gov>

Detection laboratory helps meet food safety needs



Photo by Mark Claesgens

The Rapid Microbial Detection and Food Safety Assurance Laboratory was established under the direction of Wanda J. Lyon, a professor in the Food Science Department, to work with Louisiana meat processors and food manufacturers to assist them with their HACCP (Hazard Analysis and Critical Control Points) plans. (See page 6.) The facility includes state-of-the-art equipment to detect pathogens and toxins in all types of foods. This laboratory has a proven record of assisting food processors in their efforts to address microbial hazards. The laboratory was equipped by funds provided by the state Department of Agriculture and Forestry and is housed in the Agricultural Chemistry Building on the LSU campus in Baton Rouge, La. The LSU Agricultural Center is seeking funds through the legislature to support this laboratory and other food safety extension activities.

Inside:

- *The LAES contributes to this country's safe food supply. Page 4*
- *Seafood is big business in Louisiana and safe because of HACCP. Page 6*
- *New bar code will help monitor food safety. Page 8*
- *Louisiana consumers want to know what country their meat comes from.Page 11*
- *Ozone is a new weapon in the food contamination battle. Page 12*

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