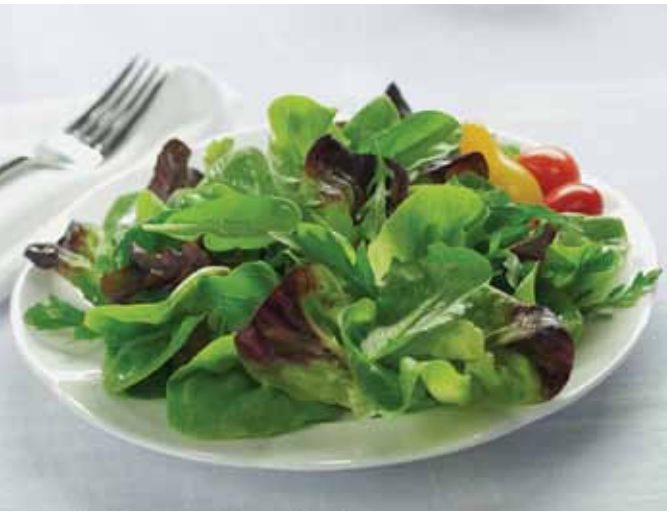
by Neil H. Mermelstein

Fresh-Cut Produce Quality & Safety

Packaged, ready-to-eat, fresh-cut fruits and vegetables are providing consumers with unprecedented convenience. The produce is harvested, cleaned, washed with a sanitizer, rinsed, dried, optionally combined with other varieties to prepare salad mixes, packaged in special packages designed to maintain quality, and distributed throughout the country for use by consumers. Because produce deteriorates with time as a result of physiological changes and microbiological action, researchers in government, university, and company laboratories continually look for ways to improve the safety and quality of these products.



Salads ready to eat right from the package *without requiring further washing provide unprecedented convenience for consumers.* Photo courtesy of Fresh Express

Multi-State Research Program

Stating that "since each product has unique physiology and handling requirements, an integrated, scientific approach to research and development on these products is critically needed," the U.S. Dept. of Agriculture's National Institute of Food and Agriculture has been conducting five-year multi-state grant programs to coordinate research on fresh-cut fruits and vegetables. The current five-year program, "S294: Quality and Safety of Fresh-Cut Vegetables and Fruits," began in October 2011 and involves 44 researchers in university and government laboratories in 15 states in the United States plus two research centers in Canada and one laboratory each in Italy and Spain.

By the end of 2012, the researchers expect to have compiled the methods being used for consumer and sensory panel testing of fresh-cut products and developed guidelines for standard sensory and instrumental measures of flavor quality for use in further research, organized a task force to develop the procedures for assessing food safety risks in fresh-cut processing, and identified the most-promising intervention strategies to reduce microbial populations on fresh-cut products. By the end of 2013, they expect to have identified fruit and vegetable cultivars that possess the highest levels of flavor quality factors and nutritionally important components for use in further research, identified the critical factors in controlled inoculation studies with human pathogens and surrogates, initiated collaborations for multi-station coordinated testing of sanitizers and for measuring shelf life of fresh-cut products, and obtained stakeholder feedback on procedures and planned activities.

By the end of 2014, they expect to have established collaborations between participating institutions for research on new pre-cutting and post-cutting treatments, including packaging to better maintain fresh-cut product quality. By the end of 2015, they expect to have identified additional or alternative intervention strategies to investigate for controlling human pathogens on fresh-cut produce, prioritized the approaches, and conducted collaborative studies; and identified other pre-cutting and post-cutting treatments to better maintain fresh-cut product quality, prioritized the approaches, and conducted collaborative studies. And by the end of September 2016, they expect to have developed best-practice guidance for research and standardized methods for risk assessments of fresh-cut product, quality-enhancing treatments, and efficacy of disinfection measures.

The S294 Technical Committee plans to issue an annual report and a final report at the end of the project. Researchers may also submit

Sunlight, humidity, and temperature fluctuations and competing microflora *can make fresh produce and the soil it's growing in very hostile environments for human pathogens.*

their findings to peer-reviewed journals and other publications. S294 holds an annual meeting each May in conjunction with the United Fresh Produce Association's annual trade show.

What Companies Are Doing

The largest retail marketers of fresh-cut salads in the United States are Fresh Express, a subsidiary of Chiquita Brands International Inc., and Dole Fresh Vegetables, a division of Dole Food Company Inc. Earthbound Farm is the largest supplier of organic produce, and Taylor Farms is the leading provider of fresh-cut produce for the foodservice industry.

• **Fresh Express** (www.freshexpress.com) in 1989 was the first company to successfully package and nationally distribute a fresh-cut, ready-to-eat salad. The company applies its *Fresh Rinse*™ wash—a combination of lactic acid and peracetic acid that has been shown to clean certain leafy greens better than chlorine washes—and packages the produce in the company's *Keep-Crisp*® breathable bag that is custom-made for each individual salad blend to allow just the right amount of oxygen in and carbon dioxide out to maintain optimum freshness. The company has comprehensive risk-management and prevention-based programs; conducts hundreds of training sessions, workshops, and forums each year to ensure that core competencies remain strong and expectations for food safety are met; and invests heavily in research and innovation. Its *Fresh Express 7 Steps of Prevention*™ food safety program is a comprehensive set of practices and standards that are in place throughout all stages of the salad-making process. The program includes meeting Good Agricultural Practices, Good Manufacturing Practices, and HACCP principles and provides a fully integrated traceability system and rapid response system. In August 2010, the company received the International Association for Food Protection's Black Pearl Award for Corporate Excellence in Food Protection and Quality.

• **Dole** (www.dole.com) has in place a comprehensive risk-based food safety program covering all aspects of its operations from the field to its packaged salads processing plants. The program is maintained by training and retraining and by attention to even the smallest detail. Independent third-party audits, conducted annually, verify the program's performance, and all fresh vegetable operations are Global Food Safety Initiative certified. The company's R&D department is working on approaches to prevent contamination at its source and on methods to improve the efficacy of post-harvest intervention processes.

• **Earthbound Farm** (www.ebfarm.com) has a food safety program and a rigorous environmental testing program in place, including zone sampling for *Listeria*, generic *Escherichia coli* testing in the plant, and monitoring of air for yeast and mold. In 2006 the company was at the center of a spinach *E. coli* outbreak despite the fact that it followed industry best practices and standards. Within two weeks of the outbreak, the company developed its Multi-Hurdle Food Safety Program. The company now tests each lot of fresh produce for pathogens of public health concern (*E. coli* O157:H7, non-O157 enterohemorrhagic *E. coli*, *Salmonella,* and *Shigella*) upon arrival from a farm and again when packaged products roll off processing lines. All lots are held until test results release them, and any lots that test positive are destroyed. The company can trace the source of any contamination back to the farm within 2 hr of obtaining a positive result, and a team can reach the

Freshly harvested produce is washed before being packaged. *Above is Dole's lettuce being washed, and below is Fresh Express's leafy greens being washed.*

Fresh-Cut Produce Quality & Safety continued...

See-through packages *provide visual attraction for retail marketers of fresh-cut produce.*

field within 24 hr after harvest. The company also implemented prevention measures in its fields and plants, including pathogen testing of all inputs and water, inspections of harvest equipment, and additional food safety audits of workers. In April 2012, Earthbound Farm received the 2012 NSF Food Safety Leadership Award for Systems Improvement from NSF International in recognition of the development of the company's Multi-Hurdle Food Safety Program.

Advances and Challenges

Various experts share what they consider to be the most recent and valuable advances regarding the quality and safety of fresh-cut produce and the challenges that lie ahead.

• **Advances.** Charles F. Forney, Postharvest Physiologist at the Atlantic Food and Horticulture Research Centre of Agriculture & Agri-Food Canada and Chair of the S294 Technical Committee, said that the industry has worked hard to extend shelf life and ensure the safety of fresh-cut fruits and vegetables. The incorporation of Good Agricultural Practices in the production of fresh-cut produce, he said, has helped to identify and control critical factors impacting quality and safety. Innovations in the application of modified-atmosphere packaging have aided in maintaining quality, reducing microbial growth, and extending shelf life. The development of anti-browning treatments has also helped improve the quality of fresh-cut fruits and vegetables.

Adel A. Kader, Professor Emeritus of Postharvest Physiology at the University of California, Davis, said that there is now more attention to flavor quality in the cultivars that are being developed for fresh-cut products, proper management of fruit ripening before cutting, and selection of packages that help maintain freshness and flavor quality. Continued efforts in this direction are critical to successful marketability of fresh-cut products, he said. Although many improvements in microbial testing procedures have been made, the value of testing is limited by the frequency and number of samples taken per lot.

Thomas E. Mack, Vice-President, Technical Services at Dole Fresh Vegetables, said that the most important advance in recent history regarding the quality and safety of fresh-cut produce is the founding and implementation of the California Leafy Green Products Handler Marketing Agreement, which sets safety standards for agricultural practices used in the production of leafy greens. It's a voluntary program that sets mandatory standards for its signatories. Conformance to the standards is verified by audits conducted by federally trained inspectors from the California Dept. of Food and Agriculture. Arizona has a similar agreement, and the two states account for more than 95% of the U.S. production of leafy greens. Establishment of the agreement, he said, raised the bar for the entire industry.

Michael J. Burness, Vice-President of Global Quality & Food Safety at Chiquita Brands, said that the most valuable advance has been in the speed and quantity of research, which in turn has become the force behind innovation and further enhancement of food safety standards. This is in large part due, he said, to the increased willingness to invest in research and the practical application of outcomes of recent research projects. Beginning in 2008 when the Fresh Express Scientific Advisory Panel recommended nine compelling research projects for a total funding commitment by Chiquita of $2 million, there was a new awareness that sound science and applied research could become the drivers of tangible improvements and mitigation strategies to enhance food safety. After that effort, industry and academia responded, the Fresh Produce Research Council was born, and a spate of promising research findings began to impact the fresh-cut industry's daily approaches to food safety and quality innovation.

Will Daniels, Senior Vice President, Operations and Organic Integrity at Earthbound Farm, said that the most significant advance in testing of fresh-cut produce is the evolution of the polymerase chain reaction test, which can tell within 12 hr–16 hr whether pathogens of public health concern are in the samples. This rapid turnaround makes a test-and-hold program possible for highly perishable fresh produce when every hour counts. Previously, when the company had to rely on culture confirmation tests that took 3–5 days, he said, test-and-hold was not practical.

David E. Gombas, Senior Vice President, Food Safety and Technology, at United Fresh Produce Association (www.unitedfresh.org), said that lots of remarkable research work is being done with regard to quality and safety of fresh-cut produce. One of the most significant advances is that researchers have realized that what happens in the laboratory is not necessarily a good predictor of what actually happens in the field. Sunlight, humidity, and temperature fluctuations and competing microflora can

make fresh produce and the soil it's growing in very hostile environments for human pathogens. Researchers are finding very complex interactions occurring, some of which favor pathogen survival and many that don't, and they are finding that predicting the fate of pathogens on produce is not as simple as previous laboratory studies seemed to indicate. So an emerging group of produce safety researchers are leaving their test tubes in the lab and putting on boots to do their work in the fields.

• **Challenges.** Forney said that ensuring the safety of fresh-cut produce remains a major challenge for the industry. Rapid methods for the detection and enumeration of human pathogens on fresh produce are needed. In addition, more effective technologies to eliminate microbial contamination while maintaining the fresh quality of the product must be developed. More attention to the flavor quality of fresh-cut produce is also needed. Technologies to maintain and enhance product flavor must be developed to ensure consumer satisfaction through the end of product shelf life.

Kader said that challenges ahead include developing a kill step for human pathogens to ensure safety of fresh-cut products, improving the reliability and speed of microbial testing procedures, mechanizing preparation of fresh-cut fruit products to reduce labor costs, and cutting only the fruits and vegetables that have good flavor as judged by the majority of consumers. Mack said that the biggest challenge ahead is the development of more-effective and -efficient intervention steps. Produce grows in an outdoor natural environment where pathogens can exist, he said, so the major challenge is to minimize microbial contamination in the field and minimize or eliminate it in further processing. Industry has relied on antimicrobial washes and has substantially improved its practices to reduce the frequency of contamination by pathogens, he said, but still needs development of a kill step.

Burness said that the fresh-cut produce industry is unlike any other due to the complexity of the supply chain; the multiple checks and balances that must be in place at every stage to deliver both quality and safety; and the ever-changing expectations of consumers for even more varieties, greater convenience, and greater access. The challenge, he said, becomes how to meet and exceed those expectations with highly perishable products while ensuring consistent quality and safety standards on a global basis regardless of geography, seasonality, nature, or countless other factors.

Daniels said that one of the major challenges is gaining greater acceptance of the value of pathogen testing throughout the industry. Another is getting all pathogens of concern added to the test regimen. For example, he would like to do *Listeria* testing on Earthbound Farm's finished products as part of the company's test-and-hold program, but right now the company can't get the test turned around fast enough. He added that there is increasing concern about emerging pathogens such as norovirus, which is not easily detected or controlled and is quickly becoming the predominant cause of foodborne illness.

Gombas said that with the absence of a kill step for pathogens, the only way of ensuring safety is prevention of contamination all along the supply chain, and the industry has gotten very good at it. One billion servings of fresh-cut produce are consumed in the United States each day, he said, and about 2 billion packages of fresh-cut salads are sold each year with very few outbreaks or illnesses. According to the U.S. Food and Drug Administration, 73 foodborne outbreaks were linked to fresh fruits and vegetables, including 22 linked to fresh-cut produce, between 2000 and 2010, the last year for which data are available. That's a pretty good safety record, he said, but any outbreak, any illness, is one too many. **FT**

Fresh-Cut Produce **Events**

The United Fresh Produce Association will present its *Produce Inspection Training Program* in Fredericksburg, Va., September 10–14, 2012. The program, presented in partnership with the U.S. Dept. of Agriculture's Agricultural Marketing Service, consists of a two-day course on *Fundamentals of Produce Inspection* and a three-day *Commodity Labs Course* that applies the principles learned in the fundamentals course to real product inspections on a range of commodities. Details are available at www.unitedfresh.org.

The *17th Annual Fresh-Cut Products Workshop* presented by the University of California, Davis's Postharvest Technology Center will be held September 18–20, 2012. The workshop will provide an overview of the production, processing, packaging, distribution, and quality assurance of fresh-cut products and will include discussions on microbial food safety and the effects of temperature and modified atmospheres on fresh-cut fruit and vegetable quality. Details are available at http://postharvest.ucdavis.edu/education/freshcut.

The UGA Extension Outreach Program at the University of Georgia, Athens, presents two annual workshops cosponsored by the United Fresh Produce Association. *Developing & Implementing GAPs (Good Agricultural Practices) & GMPs (Good Manufacturing Practices) for HACCP-Based Food Safety in the Fresh Produce Industry Workshop* is presented each February, and *Hands-on HACCP for the Fresh-Cut Industry Workshop* is presented each May. Details of recently held 2012 workshops are available at www.caes.uga.edu/departments/fst/extension/EFS_training.html#FreshProduce.

The *5th European Short Course on Quality & Safety of Fresh-Cut Produce* was held in Berlin, Germany, February 6–8, 2012. No decision has been made yet about the next short course, but there are preliminary discussions about holding it in Antalya, Turkey, in 2013.

Professional societies also hold annual meetings at which researchers present and discuss their research findings, including those on fresh and fresh-cut produce. Such organizations include the Institute of Food Technologists (www.ift.org), the American Society for Horticultural Science (www.ashs.org), and the International Society for Horticultural Science (www.ishs.org).

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