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Farm to Fork Quality Assurance

Safe Trace

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SAFE TRACE

RFID technology is one tool for ensuring traceability through the food chain

COVER STORY BY **JOHN M. RYAN, PHD**

FOR THE PAST 100 YEARS, the Food and Drug Administration and the U.S. Department of Agriculture have put most of their money into visual inspection capabilities. Many of the people conducting these visual inspections are called marketing specialists, a term that implies a focus on making sure things look good rather than making sure they are good.

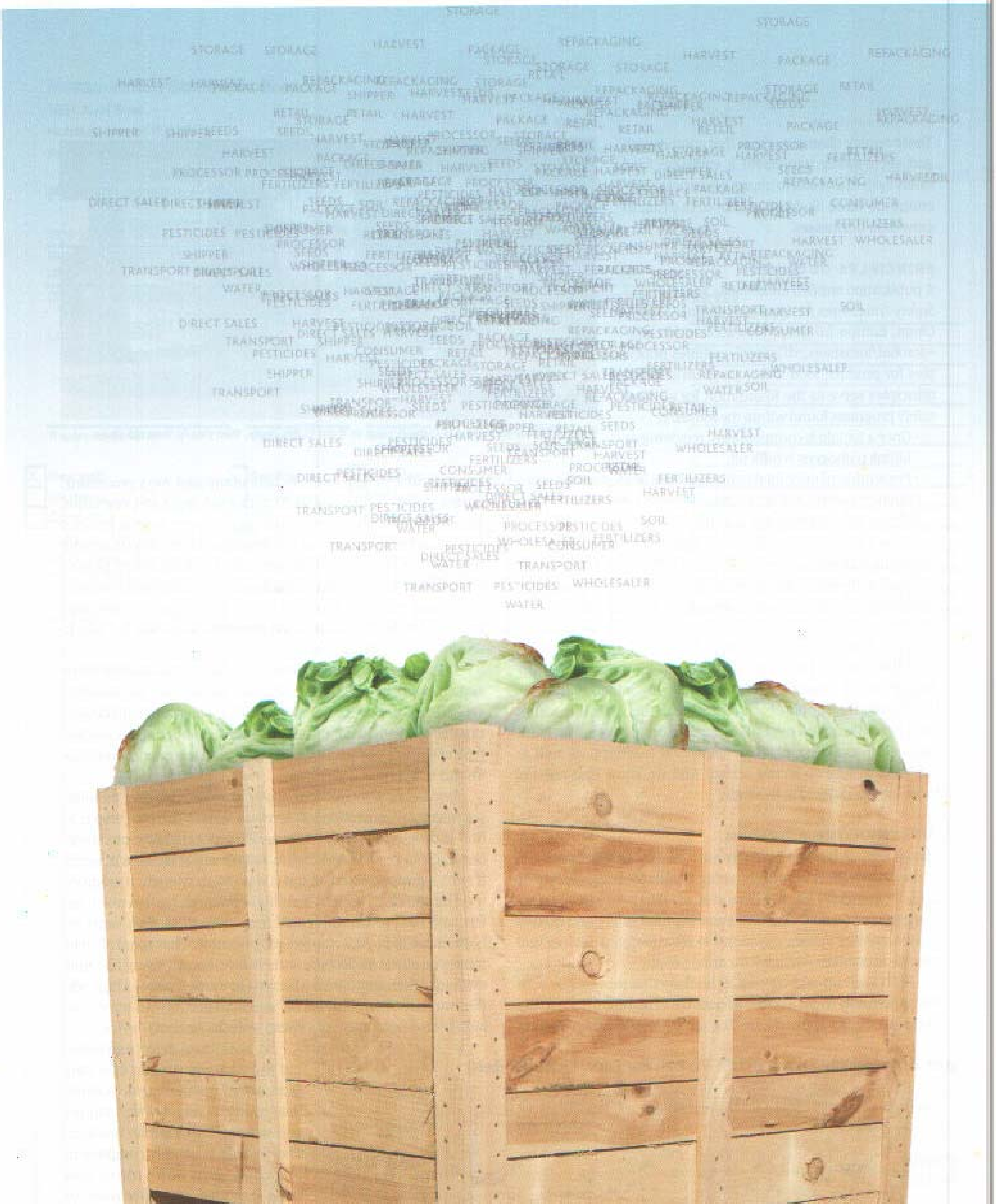
Coming from a background where implementing world-class quality systems is paramount to the success of most electronics manufacturers, it is easy to see the shortcomings in America's food supply chain. Visual inspection never has helped to provide quality products—and never will. The products will look good, but quality will always remain in question. In the technology producing world, materials are tracked, tests are performed to determine most aspects of quality, and strong controls are implemented that allow manufacturers to identify, isolate, remove, and destroy defective products. In that world, a manufacturer whose product kills people ends up paying or going out of business.

This is apparently not true in agriculture or the food supply chain.

As an example, traceability of produce is rare. If you can't find out where it came from, you cannot sue anyone. No one quickly becomes responsible for an *Escherichia coli* or *Salmonella* outbreak. The food supply chain needs traceability capabilities, measurement devices, feedback, and closed-loop controls to get a handle on such situations. That's where the term "quality control" comes from. The implication is that quality can be controlled. If we could not control the quality, the system might be called "quality out of control."

In the case of food with safety—replace the word safety with the word quality—problems, it can be said that the situation in our country is food safety out of control. And it is. This isn't hard to understand from a quality perspective. We have no traceability, no measurement of biological or chemical contaminants, no feedback loops, and no plan or people trained to control a system gone haywire before the problem enters the public domain. If we cannot keep the problem within our own walls, we will probably be sued and go out of business.

Fortunately, modern quality system strategies are slowly but surely making their way into the food supply chain realm. While a great deal of work remains to be done with regard to the costs and technological capabilities surrounding radio frequency identification (RFID) and sensor technology, risk assessment, traceability, and food safety certification are clearly being pressed by the industry and will most likely soon be required by legislation. The food supply chain member that is kept out of the marketplace because it cannot or will not comply with food safety requirements will not exist in the future. (Continued on p. 16)



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Those supply chain members that comply with and successfully implement a complete food safety system as a tool to improve business operations are more likely to be able to use that to grow their businesses.

PRINCIPLES OUTLINED

A publication entitled *Commodity Specific Food Safety Guidelines for the Fresh Tomato Supply Chain, Edition 1.0* (http://www.cfsan.fda.gov/~acrobat/tomatsup.pdf) clearly outlines principles for produce food safety programs: "Basic principles serve as the foundation for all food safety programs found within the industry:

- Once a tomato is contaminated, removing or killing pathogens is difficult.
- Prevention of microbial contamination at all steps from production to distribution is strongly favored over treatments to eliminate contamination after it has occurred."

Principle four of the nine basic principles of microbial safety states the following: "Minimize the potential of microbial contamination from agricultural water used with fresh vegetables by monitoring, documentation, and analysis of all agricultural water sources."

Let's assume we are attempting to apply world-class quality principles to the development of closed-loop quality control focused on the prevention of microbial contamination in water throughout the supply chain. Many think this is an impossible task. Regardless, how might we approach this problem? We know we need traceability, measurement, and feedback, as well as someone to take corrective action. And we know that none of those are operational at this time.

IMPLEMENTING A SYSTEM

Famed statistician and business guru W. Edwards Deming, one of the early leaders in implementing quality systems, reportedly said, "If you don't know where to start, start somewhere." One place to start when it comes to ensuring food safety and quality is a traceability system connected to measurement devices that provide immediate feedback to caring people.

RFID is an up-and-coming technology that provides us with the opportunity to get as close as possible to real-time traceability in the produce supply chain. The technology, while not yet at optimal price or use levels in agriculture and food processing, comes closest to allowing us to track fresh fruits and vegetables through the supply chain. Slap a tag on a case, scan it before it leaves the farm and again when it enters and leaves the distributor and when it arrives at the retailer, and you have a very positive track system that also lends itself to reverse traceability. Instead of tracking materials through a factory-level manufacturing line, produce can be tracked through the entire food supply chain in an almost real-time manner.

Figure 1.

If a shipment of produce sits in the hot sun as it did in this photo, then clearly, the cold chain has been broken.

Certainly, barcodes or even manual data entry to a centralized system can help with traceability. But neither has near real-time capabilities, nor do they allow us to attach measurement devices capable of communicating out-of-control conditions back to some type of control system. RFID seems to hold the greatest promise for this situation.

Remember principle four above, the one regarding monitoring microbial contamination levels in water? The next step is to find or develop some type of measurement capability, preferably one that can provide real-time measurement of bacteria in water. If such a device existed, and if it was cheap enough, it might be used by millions. Farmers, distribution centers, homes, retail outlets, and even restaurants could frequently check their water for harmful bacteria. Alas, the federal government has spent all of its money on visual inspection, so there is no known cheap real-time method of detecting harmful bacteria in water. It seems a little odd that we have spent billions on visual inspection but almost no money on development of a cheap water bioanalysis device.

So, how do we detect and measure the bacterial content of water? Our current measurement capabilities involve taking a water sample and sending it to a lab for analysis. The analysis is usually complete in two to four days, with a report most often delivered within a week or two. Think about that for a moment. Suppose there is a week lag time between taking the water sample and receipt of the lab results, and the re-

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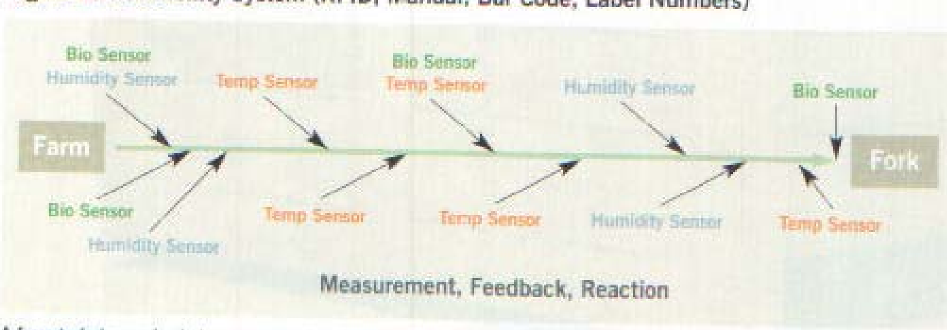
Figure 2. Traceability System (RFID, Manual, Bar Code, Label Numbers)



A farm to fork supply chain can use various types of sensors that feed data into a radio frequency identification (RFID) backbone.

ALL IMAGES COURTESY OF JOHN M. RYAN, PHD

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sults show high levels of contamination. Suppose that the water sample was taken at a farm. Does the farmer wait a week before shipping the produce? Probably not. Where is the produce after a week? Most likely the produce is in your refrigerator or in the salad you will eat in the next five minutes.

Suppose the water sample was taken from the produce section of your local supermarket? Where is the produce a week later? How many people have eaten it? Get the picture? There is simply no control over the safety—read quality—of food in our food supply chain. More importantly, there is no set direction for developing such control systems.

The theory is that the water activity levels in produce keep bacterial levels low. Water activity levels are more or less controlled by temperature. That's why we have developed refrigerators. That is also why responsible supply chain members have developed what is called the cold chain. If a farmer harvests lettuce and quickly refrigerates it (many do), and the lettuce is processed and shipped in refrigerated trucks, boats, and planes (it often is), and it is delivered to refrigerated distribution centers and then into coolers in retail outlets, you have a cold chain. From a farm to an often very cool retail shelf, the produce is somewhat protected, its water activity level at a non-bacterial producing level.

But things do go awry, an example of which can be seen in Figure 1 (see p. 16), a photo of a shipment of bagged spinach and broccoli that had been air freighted into Hawaii in temperature protective packaging but ended up sitting on the blacktop at a freight forwarder at a temperature of 91°F. This is an example of a broken cold chain. Either that or there is no need to steam the spinach when the consumer takes it home.

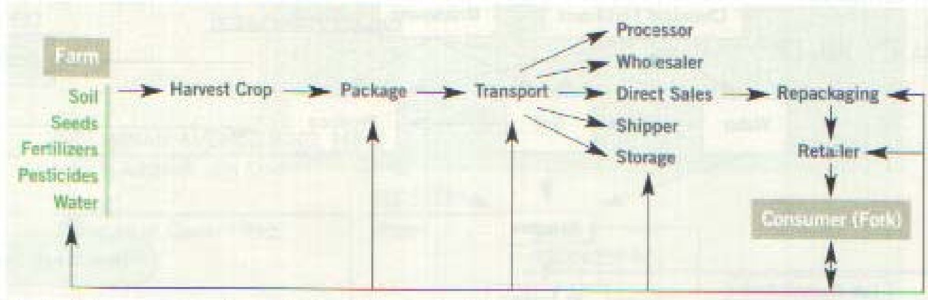
> RFID is an up-and-coming technology that provides us with the opportunity to get as close to real-time traceability in the produce supply chain as we can get. The technology, while not yet at optimal price or use levels in agriculture and food processing, comes closest to allowing us to track fresh fruits and vegetables through the supply chain.

COLLECTING, TRANSMITTING DATA

Suppose we did have the capability of measuring temperature and microbes throughout the supply chain. Also suppose we could use an RFID system to collect and transmit measurement data to a centralized system? What might it look like? Figure 2 (see p. 16) depicts a farm-to-fork supply chain with various types of measurement devices—sensors—feeding data into an RFID backbone.

Think about feedback this way. Customers taking produce off of a retail shelf are creating demand. They are pulling food through the supply chain. They create a pull system. When the produce manager sees the shelf running low, he pulls produce from the store cooler and restocks the shelf. The cooler manager sees the inventory in the cooler at a low level and calls the distributor to get more shipped. The distributor ships to the store, thus reducing the distributor inventory levels, so the farmer is notified to bring more into the distributor the next day. Produce flows like money though our hands. It rarely stops for long—if things are working correctly.

Figure 3. The Supply Chain and Feedback Loops



Feedback from sensors can be used to track food through the supply line and determine if the cold chain has been broken.

If we study sensor measurement a different way (see Figure 3, above) and add the third dimension, feedback, we can quickly envision a system that is measuring, communicating, and feeding data back to the next operation, data that may be used to study previous operations. The farmer, for example, can watch measurements of his produce through all later steps in the supply chain: packaging, transportation, retail, and so on. And if the retailer sees a problem, the data trail for a particular case can be recalled, analyzed, and worked on. In the case of a retailer receiving wilted lettuce, the system can quickly identify where the cold chain was broken.

Of more critical importance is the ability of the system to issue alerts when the cold chain is broken or when microbial contaminants are discovered. It is this alert capability that allows us to begin controlling food safety and quality. Again, the closer the data is to real time, the quicker we can intercept, remove, isolate, and eliminate potentially dangerous produce or meat—or any poor quality food.

RFID SEARCHES FOR ITS PLACE

A traceability system that exists only for the purpose of traceability or for business improvement purposes has not yet found its proper place in the world. Traceability—indeed RFID-enabled traceability—provides the backbone for establishing food supply chain quality controls.

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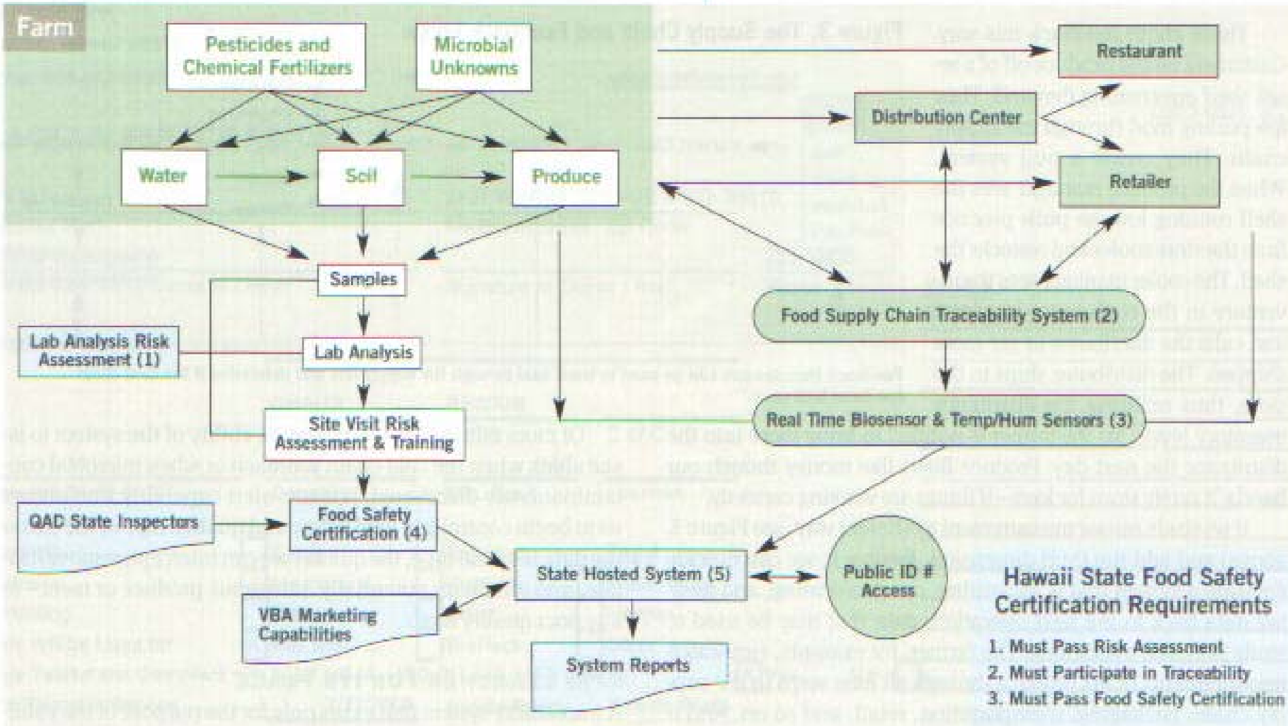
Figure 4. Flow Diagram



A number of concepts can be combined into an integrated food safety certification system. It is important to remember that risk assessment criteria must be established for any point in the supply chain.

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In spite of the weaknesses inherent in visual inspection, refocusing current food safety inspection specialists will allow a broader penetration of the market while improving the ability to assure food safety. Current audit strategies use 20- to 30-page checklists full of rubber ruler data strategies.

Audits that spend time, energy, and money rating various processes with statements such as the following are simply a waste of time because they meet no known measurement reliability or repeatability criteria:

- Water quality is known to be adequate for the crop irrigation method and/or chemical application.
- If necessary, steps are taken to protect irrigation water from potential contamination.
- The farm sewage treatment system is functioning properly and there is no evidence of leaking or runoff.
- Processing water is sufficiently treated to reduce microbial contamination.

What, exactly, is meant by "adequate," "sufficient," or "proper?" Why spend time and money on such inadequate measurement attempts? Again, the ability to separate, isolate, control, and recall is paramount, but these are only a few of the issues involved with traceability.

Laboratory analysis is a basic requirement if water, soil, and produce samples are to be analyzed for the multitude of chemical and biological contaminants that can and do impact food supplies.

Detection or measurement is one thing, but creating an independent device capable of measuring and forwarding its data in a real-time manner to a centralized system designed to deliver alerts is a completely different animal.

INTEGRATED FOOD SAFETY CERTIFICATION

Figure 4 (above) illustrates a combination of the concepts above into an integrated food safety certification system. In order for certification to occur, three criteria must be met:

- risk assessment;
- traceability; and
- certification.

While the figure focuses on the farm as a starting point, risk assessment criteria must be established for any point in the supply chain. This includes farms, distribution centers, wholesalers, transporters, and retail or restaurant outlets. Regardless of the size of the operation, food safety risks do not go away. The farm, for example, commonly puts some type of fertilizer on the soil and occasionally on the produce. Chemical fertilizers and pesticides used by most farms or the organic composts used by organic farmers need to be tested, as does the water on those farms. Tests should occur more than on an annual basis and should be accompanied by a stop order if test results are not up to specifications.

In today's world, when water is tested and found to have unacceptable levels of *E. coli*, there is no obligation to stop using that water. If there was a higher level of chemical and biological surveillance, however, a great number of food production and handling operations would be put out of business for their apparent lack of regard for human health.

Figure 4 puts risk assessment, traceability, and an overhauled food safety inspection system into each other's contexts. Given a farm—designated USHI9Y4—with unavoidable chemical and biological contaminants in its soil and water and on its produce, samples are taken for the laboratory analysis part of the risk assessment. A focused primary risk assessment walk-through audit is conducted on the farm at the same time the water, soil, and produce samples are collected. The walk-through audit evaluates risks while teaching the farmer about the type and extent of risks the farm exhibits.

Once the primary risk assessment is complete and the traceability system is in place and operational, inspection staff are called in to provide a complete food safety certification study. It should be noted that passing the inspection for food safety certification is not sufficient for food safety certification in this system. The business entity must pass risk assessment, be a firm member of a traceability system, and pass a complete food safety audit.

Meanwhile, as the produce is shipped to distributors, stores, and restaurants, the operating traceability system is tagging and tracking cases and pallets. More importantly, temperature and biological sensors are measuring and communicating the results of their measurements to the RFID system.

Furthermore, all data related to the certification status must be housed in a hosted computer system that makes nonproprietary data available to corporate buyers and the general public. Public access to the system is provided using the USHI (Hawaii) business identifier associated with shipped produce. Note that the USHI not only meets country of origin labeling (COOL/U.S.) and traceability requirements; it also traces the produce back to the state of origin (Hawaii) and the specific farm of origin (USHI9Y4). Any person anywhere in the world can enter that number into the hosting system and quickly locate the specific farm from which the produce came. More importantly, the person entering the data can review that farm's food safety certification status.

The business owner benefits because the business then becomes a member of a formal food safety certification system that can be used to provide substantial marketing power. Let's face it, top-down pressures from wholesalers, retail chains, and restaurant chains are actively enforcing food safety compliance. There is no escape, even for the small farmer. Compliance is market driven due to increasing public awareness of the state of the industry with regard to *E. coli*, *Salmonella*, and other food safety failures.

A farm with good risk assessment data is part of a solid traceability system, tracks the temperatures of its shipped produce, and has passed a full food safety certification audit, putting it in a good position to create demand. Buyers aren't looking for farms that continually make excuses about why they cannot achieve compliance. Such farms are simply placed on the "does not qualify" list.

Modern quality system strategies are slowly but surely making their way into the food supply chain. While a great deal of work remains to be done with regard to costs and technological capabilities surrounding RFID and sensor technology, risk assessment, traceability, and food safety certification are clearly being pressed by the industry and will most likely soon be required by legislation. The food supply chain member that finds itself kept out of the marketplace because it cannot or will not comply with food safety requirements will not exist in the future. ■

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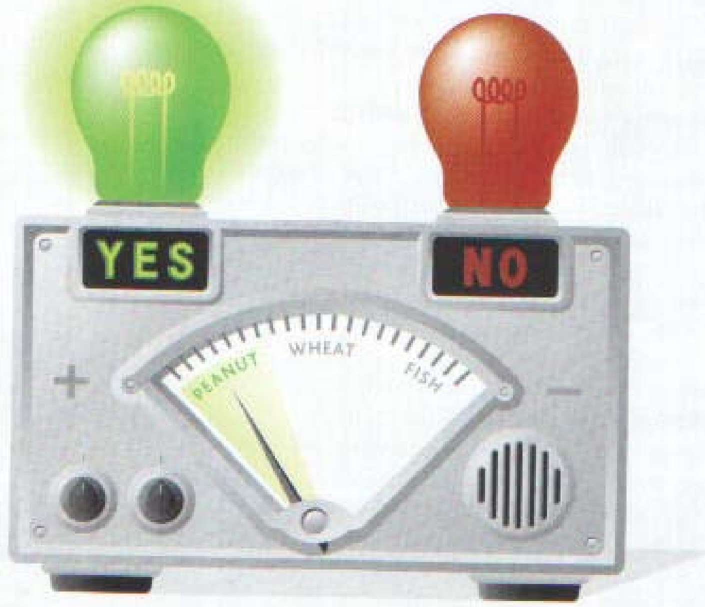

Protect Your Company From Food Allergens

Learn how to test for allergens and protect your reputation

BY ARLENE K. SCHAG

He was 12 years old when he ate his last meal. He did not know what anaphylactic shock was, but that's what happened to him after traces of peanut in his food triggered a severe immune response.

His lungs were transplanted into a 42-year-old female with no prior history of peanut allergy. Seven months after the transplant, she suffered anaphylactic shock after eating a peanut butter cookie. She survived but suffered a second anaphylactic shock later that same year. After doctors questioned her, she recalled that the first episode had occurred four days after the transplant. Skin prick testing confirmed sensitization to peanuts. This kind of peanut allergy transfer from donor to recipient has also been described after liver transplantation.

Food allergies happen when a person's immune system reacts to proteins in what he or she has eaten. In an attempt to protect the body, the immune system produces antibodies to that food. Those antibodies then cause mast cells—allergy cells in the body—to release chemicals, one of which is histamine, into the bloodstream. Histamine then acts on a person's eyes, nose, throat, lungs, skin, or gastrointestinal tract, causing the symptoms of the allergic reaction.

According to the Food Allergy & Anaphylaxis Network (FAAN), one in 25 adults and one in 17 children have food allergies. Statistics like these indicate a need for reliable manufacturing practices such as testing and proper labeling.

ALLERGIC REACTIONS

Once an allergic reaction begins—a true food allergy, not a food intolerance—it is impossible to predict how severe it will become. It has been observed that an allergy that persists into teenage or adult life is less likely to disappear.

Www.webmd.com explains how the timing and location of an allergic reaction depend on the complex process of digestion. For example, a person who is allergic to a particular food may first experience itching or tingling in the mouth. After the food is digested, abdominal symptoms such as vomiting, diarrhea, or pain may ensue.

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