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California Polytechnic Studies E. coli and Bagged Greens

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Researchers will use RFID sensor tags to measure the real-time temperature and humidity levels of lettuce and spinach during shipment from packer to retailer, then replicate those conditions in a lab.

By Claire Swedberg

Oct. 9, 2009—With a $600,000 National Integrated Food Safety Initiative (NIFSI) grant from the U.S. Department of Agriculture (USDA), a team of researchers from several universities are embarking on a three-year study using RFID sensors to track the temperature and humidity conditions of leafy green vegetables in the supply chain. Led by a group of scientists at California Polytechnic State University, the study—which is expected to be fully underway in the first quarter of 2010—is intended to determine when, and under what conditions, food-borne illness contamination develops in "at risk" product (in this case, bagged spinach and lettuce).

The researchers will place the RFID sensors in produce containers within trucks used to ship the food, in order to measure temperature and humidity levels, as well as when fluctuations occur and how they may correspond with the incidence of *Escherichia coli (E. coli)* and other pathogens in produce sold by retailers. For example, the humidity level can affect the permeability of the plastic bag in which greens are packaged, thereby reducing the product's shelf-life. Researchers also hope to use the study's results to provide training for packaging and distribution professionals, in order to prevent food-borne illness through the monitoring of fresh products during transport and distribution.

California Polytechnic assistant professor Keith Vorst

The study, part of a project entitled "A Systems Approach to Minimize Escherichia coli O157:H7 Food Safety Hazards Associated with Fresh- and Fresh-Cut Leafy Greens," will include at least four produce packers, as well as major retailers, trucking companies and distribution centers (DCs). The team is employing Sensor Wireless' Active Wireless Sensor (AWS) 2.4 GHz ZigBee RFID tags with built-in temperature and humidity sensors that transmit to a central receiving unit with a GPS receiver to track a truck's location and send that data via a GPRS connection.

The study will focus on leafy greens because *E. coli* has been prevalent in such produce. Since 1993, at least 25 *E. coli* outbreaks have been traced to leafy green vegetables—primarily lettuce and spinach. There has been little tracing of temperature or humidity during commercial transport of leafy greens, says Keith Vorst, an assistant professor at California Polytechnic and the study's principal investigator. For that reason, he notes, the team is interested in gaining visibility into the products' temperature under commercial transport and warehouse conditions.

The AWS technology will enable researchers to receive data regarding the conditions of lettuce and spinach shipments in real time, according to Wayd McNally, Sensor Wireless' president—though in the

early part of the study, Vorst says, the data will be examined mostly at the end of the shipment.

With the study, California Polytechnic's researchers will place AWS sensors (27 per shipment) in cartons of greens as they are loaded into trucks by the university's researchers, on the West Coast, East Coast and Midwest—with five trucks being tracked in each region. Tracking the temperatures and humidity to which each product is exposed could be made more complex due to the unloading and reloading of products at DCs, including mixed pallets containing products from multiple locations. For that reason, the sensors are being placed within the cartons rather than on pallets.

Every two minutes, the sensors will measure the temperature and humidity within the trucks at various areas around the produce, then transmit that data to a Sensor Wireless Sensor Communication Interface (SCI) unit, which functions as an RFID interrogator. The SCI, in turn, sends the information, including location, to Sensor Wireless' software on its server, via a GPRS signal. Whether the vehicle is at the loading dock or on the highway in transit, as long as there is a cellular connection, the SCI transmits the tag data every two minutes.

The Sensor Wireless software interprets the data, then makes the sensor and location results available to researchers. If the temperature or humidity level exceeds a specified threshold, the Sensor Wireless software will send an alert to a designated point of contact at California Polytechnic. With the SCIs sending information every two minutes, researchers expect to receive 720 temperature and humidity readings from each sensor for every 24-hour period, with as many as 405 sensors transmitting at any given time, depending on how many of the 15 trucks are in operation.

Each of the packing plants and DCs will be equipped with a GPRS modem, though Vorst says he expects there will be segments along the supply chain at which there will be no cellular connection. If an SCI loses its GPRS signal, it will store sensor data until coming within range of another one. At the retail store, the sensors will be removed from the cartons of produce, and reused on another shipment, and the bagged lettuce and spinach will then be sold to consumers.

In the meantime, the temperature and humidity data will be used by researchers at Michigan State University to re-create the temperature and humidity conditions that the vegetables experienced in transit. During that simulation, a batch of salad mix or other leafy greens will be inoculated with *E. coli*, and the researchers will then study the pathogens' growth.

One question Vorst hopes to resolve with this study is whether this technology could be used by the food industry to prevent food-borne illness based on pathogen growth. "There is zero tolerance of food-borne pathogens in the food supply," he states, "and yet, obviously, it's still happening." Some pathogen growth may be occurring within the supply chain, he says, yet there is still little understanding of the environmental conditions of produce in the supply chain, and precisely what results from those conditions. "There's just insufficient data out there."

This is phase one of the study. The first year of the research will consist of tracking vehicles on the

road, as well as obtaining temperature and humidity data from those shipments. The following year will be spent analyzing the information. After that, Vorst indicates, researchers will set up wireless sensing technology at retail locations to track temperatures and humidity levels where the product is kept on a store shelf or in a back room.

If the system works as expected, McNally says, Sensor Wireless' solution could be used by the food industry to track the condition of its fresh food, at a cost of approximately $200 per SCI, and $40 to $60 per month to access data from the sensors.

Following the study, California Polytechnic intends to make the results available to those in the industry, in the form of a video for food handlers, truck drivers and trucking companies, as well as food manufacturers, distributors and merchandisers. The video will also be available for use in university classrooms.