Chemical-Free Strategy Keeps Food Pest-Free

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Every day at mealtime, millions of people worldwide are joined by uninvited guests: namely, pathogens and other pests that reside in food. When consumed, the contamination often leads to dire consequences. Microbes like E.coli and salmonella harbor illness that can be fatal — and food safety problems do more than unleash an avalanche of devastating health effects. The fallout wreaks economic havoc too, in the form of market-share loss, medical care, legal fees and other costs.

Current techniques to address contamination can involve toxic chemicals, but a California-based company called RF Biocidics Inc. has taken a different approach to the problem. Developed at University of California, Davis, the technology gives commercial food producers a chemical-free path to food safety — without diminishing taste, texture or nutrition. And that's just the beginning, because this process has potential disinfection applications that extend far beyond the dinner plate.

Unwelcome Ingredients

Hardly a month goes by without headlines announcing another outbreak of unwanted microbes in the food supply. The cumulative effect leads to some startling figures.

> *Approximately 1 in 6 U.S. residents contract a foodborne disease each year. Of those, 128,000 end up in the hospital and 3,000 die, according to the Centers for Disease Control. And that represents only one corner of the globe.*

Consider the repercussions from a salmonella outbreak that originated about five years ago at a U.S. peanut butter manufacturer. The products sickened more than 625 people in 47 states and may have led to nine deaths. The recall involved 326 million pounds of peanut butter, and the manufacturer, Peanut Corporation of America, ultimately filed for Chapter 7 bankruptcy.

That single example underscores a two-fold effect shared by other outbreaks: Not only do they sicken people, they also don't do any favors for economic health. According to the Pew Health Group, the total cost of foodborne disease to the U.S. economy is estimated at more than $152 billion annually.

New Purpose for a Familiar Technology

To make food safer, RF Biocidics uses heat. That may not sound particularly innovative, considering heat has been used for decades to destroy pathogens in certain foods, like the pasteurization of milk and juice. But the innovation resides in the heat source, which employs a new use for a familiar technology: radio frequency.

First developed a century ago, radio frequency (RF) is used for wireless communication around the world, transmitting data, sound and video. In this case, it's used to prevent the transmission of food-borne illness. The process is called RF thermal processing, and it applies electric power to create an oscillating electric field that is converted into RF power. When material is exposed to that electric field, water molecules within the material start to vibrate and give off heat. That raises the temperature of the entire material.

The basic science of RF thermal processing has been around for years — for instance, the lumber industry has used it for decades to dry wood. But could it also zap bacteria and bugs without compromising food quality? In the 1990s, that question was on the mind of Manuel Lagunas-Solar, Ph.D., currently the chief scientific officer at RF Biocidics. "As you can imagine, there's a big difference between lumber and almonds, particularly in terms of commercial practices," says Lagunas-Solar.

At the time, he worked at the Crocker Nuclear Laboratory at UC Davis and had plenty of experience with radio frequency, which powered the lab's particle accelerator. "I worked there for about 42 years ... 41.7 years, actually," he says. That response hints at Lagunas-Solar's need for precision, and it's a useful mindset when applying heat to disinfect food. There's little room for error when the goal is to destroy bacteria and other pests (like moth larvae) but not food quality. "The difference between sterilization and the deterioration of food quality and nutrition can be as little as 10 degrees," says Fortunato Villamagna, Ph.D., CEO at RF Biocidics Inc.

For this process, Lagunas-Solar knew he had to work with lower frequencies that don't interfere with things like cell phone communication, radio and television broadcasts, or air traffic control. It opened up some unchartered territory, considering the scant scientific literature exploring how RF interacted with different materials — particularly food — at low frequencies.

He collaborated with co-inventors Nolan X. Zeng, Ph.D., and Timothy K. Essert (also at Crocker Nuclear Laboratory), spending seven years studying the effects of RF treatment on more than 100 foods. Their research showed that RF

treatment could effectively kill microbes and insects without overheating the food surface, making it suitable for a range of materials including nuts, seeds and spices.

Disinfection and disinfestation aren't the only benefits of the RF process. Some foods have enzymes that promote the growth of cells, and that can dramatically reduce the shelf life of those products. For example, edible seeds like pine nuts will germinate during long-term room temperature storage, leading to economic losses when the seeds' quality deteriorates. But RF treatment inactivates the enzymes. By controlling germination, it improves shelf-life stability.

Private sponsors provided early funding for the research, says Raj Gururajan, Ph.D., intellectual property officer for Technology Transfer Services at UC Davis InnovationAccess. "We're always looking to enable inventions with social and economic impact to move into the marketplace," says Gururajan. "We think it has the potential to be deployed not just in the developed world, but in the developing world too, for fast and effective disinfection of food and agricultural products," says Dushyant Pathak, associate vice chancellor, technology management and corporate relations at UC Davis.

Beyond the Lab Bench

RF Biocidics wasn't the first company to license the technology from UC Davis. The technology was initially licensed in 2001 to a different business, but it returned the technology rights to UC Davis in 2008. The technology transfer group at UC Davis worked quickly to identify a potential licensee — and found a viable partner in Allied Minds Inc., a Boston-based investment firm that focuses on university research innovations. Allied Minds formed RF Biocidics in 2008 as a startup company to hold the technology and has also provided funding for further development of the technology, including a commercial prototype.

Villamagna praised the work of the technology transfer group. "At this stage, we are working with them to manage the patent portfolio," he says. "In transferring the technology, the UC Davis office has been extremely helpful and cooperative." Lagunas-Solar echoed that sentiment. "Their role has been very important in connecting the university research with the industrial application," he says. "I think they've done an excellent job, not just with this technology but with other technologies as well."

For RF treatment, the RF Biocidics equipment moves food (or other material) via a conveyor belt through a treatment chamber. The material stays in the treatment chamber for a set period of time, depending on the type of material and the desired level of disinfection or disinfestation. RF Biocidics both sells and leases the equipment to food producers, primarily for nuts, seeds and spices. It currently has units installed in the U.S, England and Latin America.

The treatment system is approximately 35 feet long, 6 feet wide and 8 feet high — and requires a substantial investment. To help companies that can't afford to lease, RF Biocidics built a facility in California to processes material on a contract basis. "We take in customers' product, process it, put it back on a truck and send it to them. We never open the containers, so once it is pasteurized, it doesn't get re-contaminated," says Villamagna. For more than a year, the facility has processed a half-million pounds of nuts, seeds and spices. Villamagna expects that figure will soon reach 1 million pounds per month, and plans to open a second California facility this year to boost the company's processing volume.

A Safer Food Supply, from Farm to Plate

Most consumers don't recognize the contamination risks that can occur long before food reaches the grocery store shelf. Take nuts, for example. Walnuts, almonds and other nuts are collected by shaking the trees on which they grow. After the nuts fall, they're scooped up — along with other things that happen to be on the ground, like fecal matter

from animals. That's a big yuck factor — and worse, it's a source of salmonella and E. coli.

There's also a need to remove microbes from nonfood consumer products too — like essential oils in cosmetics, says Villamagna. He wants RF Biocidics to help improve the safety of anything humans ingest or absorb through their skin. "The concept of destroying pathogens, whether they are bacteria or tape worm larvae, it just spreads exponentially," he says. "Actually, when you think about it, you get the willies."

Of course, RF Biocidics has an antidote for the willies — one that doesn't require chemicals. That's important for several reasons, notes Villamagna. Current agricultural production often involves massive amount of pesticides to eradicate unwanted insects, microbes and fungal pests. That can have harmful effects for the environment, agricultural workers and possibly for consumers who end up eating trace amounts of those chemicals.

"I believe that the days of relying almost entirely on chemical applications in different phases of food production and distribution are probably going to be replaced by more friendly technologies that allow the food industry to respond to concerns from consumers to the use of chemicals," says Lagunas-Solar. "Particularly because they leave a residue in the food, and there are many concerns with what happens to the public health in general and environmental health in particular."

There's another ongoing problem with pesticides: Insects constantly adapt to them, which means scientists must fight to stay ahead of the genetic curve. RF treatment doesn't have that problem. It works on all species, and they can't adapt to survive its effects.

The creation of this technology has also led to the creation of jobs. RF Biocidics currently employs more than 40 people at facilities in the United States and the United Kingdom. Although initial use has focused on seeds, nuts and spices, it has potential for many other applications. One example is fishmeal — a type of animal feed commonly part of the diet of livestock. Another is animal waste, which plays a critical role in agriculture. "We spent a lot of time looking at animal waste from, say, dairy production," says Lagunas-Solar. Although animal waste is an important liquid source of nutrients, it's often applied to farm fields without being disinfected first. That's not the only potential agriculture application for RF treatment.

"One of these days, I think, even soil could be treated in a way that minimizes or prevents the use of chemicals, but we're not there yet," says Lagunas-Solar.

In addition to people food, RF Biocidics treats pet food. The company has already processed canary seed for one client. "Believe it or not, the animal side is equally important, in terms of preventing bird flu and other diseases," says Villamagna.

By harnessing radio frequency power for disinfection and disinfestation, RF Biocidics could play a vital role in reducing an array of illnesses. "At some point I think everything we consume will be pasteurized, and the potential volumes are enormous," says Villamagna. With RF treatment, his company provides a chemical-free, effective and reliable alternative to existing methods. "The ability that I can give my child a product to eat that I know won't hurt him — that is a very good thing," says Villamagna. "It actually makes the world a safer place."

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