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Economic Leadership

Sea Grant research leads to "fine-tuned" heating of wide array of foods

By mincing the fish, then washing it repeatedly, producers create surimi, which is then heated to form the crab- or other-flavored surimi seafood products commonly found in grocery stores and restaurants.

WHAT STARTED AS A search by Oregon State University researchers to improve the processing of surimi seafood, a product of growing importance to the Pacific Northwest, has become a patented concept that may have a wide variety of applications in the food products industry.

The initial research into "capacitive dielectric heating," a way of tuning radio frequencies to precisely heat-specific parts or materials in food, began in 1993 as an Oregon Sea Grant-funded research project aimed specifically at the specialty fish product, surimi. But the diversity in the backgrounds of those who share in the patent indicate the far greater potential of the technique.

Sharing in the patent are Ed Kolbe, a mechanical engineer associated with both Extension Sea Grant and OSU's Coastal Oregon Marine Experiment Station (COMES); Jae Park, a COMES food scientist at OSU's Seafoods Laboratory in Astoria; John Henry Wells, a packaging engineer and superintendent of OSU's Food Innovation Center in Portland; electrical engineer Benjamin Flugstad, owner of Flugstad Engineering in Port Townsend, Washington; and Yanyun Zhao, a food process engineer at OSU's Department of Food Science and Technology in Corvallis. OSU and Flugstad Engineering jointly own the patent.

Surimi is a washed fish paste made from fish that are typically underutilized as a food source. By mincing the fish, then washing it repeatedly, producers create a concentrate of fish protein, surimi, that is then heated to form the crab- or other-flavored surimi seafood products commonly found in grocery stores and restaurants.

Surimi seafood is conventionally heated by gas burners and steam. The original Sea Grant project, begun by Kolbe and Park in 1993, applied a process called "ohmic heating," which sends regular household AC electricity directly through the fish paste, generating heat as a result of electrical resistance and rapidly firming it into a gel.

Once the seafood paste is heated, processed, and packaged, a second heating step is required for pasteurization. Pasteurization involves heating to a temperature of around 185°F, typically in steam or a hot water bath, to kill most pathogenic bacteria and to extend the product's shelf life in chilled storage. Park reasoned that if the seafood could be heated internally, as in the ohmic heating process, it would reach pasteurization temperatures much sooner. Such rapid heating would increase energy efficiency and minimize loss of texture, flavor, color, and nutrients.

However, ohmic heating requires direct contact between the electrodes and product. Because the surimi is wrapped in plastic packaging by this point, ohmic heating won't work. Microwave heating is also not an option because of problems with nonuniform heating—that is, overheating the edges while insufficient heat penetrates to the product center.

Flugstad, whom Kolbe called "the brains behind this electrical engineer-based patent," was brought into the project in 1997. According to Kolbe, Flugstad, an electrical engineer whose company brings years of industrial experience in biomedical electronics, suggested a third range of frequencies that could do the job. Radio frequencies (RF) in the range of 10 to 80 megahertz, or millions of cycles a second, will make food molecules vibrate and react. This is about 100 times lower in frequency than microwaves. The lower frequency has the potential of more uniformly heating food packages wedged between electrodes.

On the basis of this idea, the collaborative research team added a new objective to extend the original Sea Grant ohmic research, and preliminary RF experiments were under way.

The researchers discovered that certain characteristics, such as frequency and voltage of the radio frequency field, could be varied to maximize the energy absorbed by the product sitting between electrodes. This is called "impedance match." They also found that narrow ranges of frequency could resonate with individual ingredients or packaging materials. This would allow specific components of the food product to be heated very precisely if the RF were tuned to those frequencies. As the components heat up, their resonance changes, and the RF can be tuned to match those changes, allowing rapid and uniform heating. This is the basic concept for the patent that was awarded.

Qingyue Ling, an agricultural engineer with the OSU Food Innovation Center, joined the team at this point, working on experimental design and instrumentation.

As expected, the "best" combination of these RF characteristics changed as the food properties changed with increasing temperature. To achieve the rapid heating and maximum energy efficiency the system is capable of, a sophisticated and rapid control system is needed to quickly switch the radio frequency to follow the best impedance match. A second patent application, submitted by Flugstad with the OSU researchers, covers the control system. That application is still pending.

As preliminary experimental design proceeded, the technology's potential for food and packaging systems far beyond surimi seafoods attracted the interest of researchers in other areas.

Zhao, from OSU's Department of Food Science and Technology, began looking at its application to sprouting alfalfa, radish, or other seeds that form sprouts for consumption, such as at salad bars and as sandwich garnishes. She was joined by Wells, from the Food Innovation Center. With Flugstad, and with help from Norma Corristan of the Oregon Department of Agriculture, the researchers secured funding from the U.S. Department of Agriculture to explore the application of RF heating to improve food safety with sprouting seeds. A second proposal by Kolbe, Park, Flugstad, and Zhao was funded by the USDA National Research Initiatives program and sought to demonstrate the rapid and uniform heating of packaged "muscle foods," such as packaged meat, poultry, and fish.

From the early Sea Grant funding that gave the team its start, work has continued under the USDA funding to look carefully at the temperature- and frequency-dependent property data for surimi seafoods, meats, plastic and edible packaging, and sprouting seeds. A series of tests showed initial success, producing rapid heating rates and uniform temperatures in both surimi gels and seeds. Results from these and other research projects have been extremely promising, Kolbe said.

The collaborators continue to pursue funding and industry partners to enable the development of a pilot facility at OSU's Food Innovation Center. With the ongoing use of mathematical models and new equipment, such a facility will enable them to explore a combination of RF and external temperature control, plus a range of configurations to bring about rapid, uniform, and energy-efficient heating.

While pasteurization of surimi seafoods is still an important commercial goal, the potential for this technology reaches far beyond seafood and the Sea Grant funding that got it all started. Sprouting seeds, packaged lunch meats, frankfurters, ready-to-eat meals, food service thawing, and other applications are potentials they hope to realize as their work progresses.

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