A Nanotech Revolution in Agriculture and the Food Industry

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On March 20, 2006, U.S. Secretary of Commerce Carlos M. Gutierrez announced the launch of a state-of-the-art center for collaborative nanotechnology research at the National Institute of Standards and Technology. "The National Center for Nanoscale Science and Technology," Gutierrez said in a press release, "will help the private sector develop innovative products like more efficient batteries, lighter-weight and higher performing materials for aircraft and autos, and smaller computer chips to power digital devices."

Nanotechnology encompasses the ability to measure, model, and control matter at dimensions of about 1 to 100 nanometers. The groundbreaking potential of nanotech derives from the unusual physical, chemical, and biological properties of nanoscale-sized matter that differ from those of individual molecules and bulk matter. These unique properties allow the development of novel applications, noted by Gutierrez, in the fields of engineering and computer science. Nanotechnology will also bring innovations to the food industry and agriculture.

Effecting Big Changes with Small Alterations in the Food Industry

The Helmut Kaiser Consultancy (Tübingen, Germany) finds nothing small about the nanofood market, predicting that the market may reach over $20 billion dollars by 2010. Around the globe, over 400 companies research, develop, and produce nanofood-related products. The general aims of nanotechnology in this arena center on improving the quality of food.

Numerous food companies seek to use nanotechnology to create safer, more nutritious, and more flavorful products. Nanotech may provide improved functional properties, such as low sodium food products that taste salty due to nanotech-induced interactions with the tongue, and functional food components tailored to the individual consumer's preferences. Nanoparticles, nanoemulsions, and nanocapsules may be designed to enhance the availability and dispersion of nutrients, antioxidants, or nutraceuticals. These beneficial factors may even be delivered to targeted areas of the body at selected times.

Research and development efforts in the nanofood industry also focus on improved food packaging. Nanotech can enable two new types of food containers: active packaging and smart packaging.

An example of active packaging is a plastic film with dispersed clay nanoparticles that prevent oxygen, carbon dioxide, and moisture from reaching food. Other types of active packaging possess antimicrobial properties.

Smart packaging incorporates nanomaterials that respond to environmental conditions, engage in self-repair, or alert a consumer to the presence of chemical or pathogen contamination. For example, nanoparticle films and other packaging with embedded sensors will detect food pathogens. These nanosensors trigger a package color change to alert consumers that the food has become contaminated or has begun to spoil. Another type of packaging may incorporate a bio-switch that releases a preservative if the food within begins to spoil.

A Nanotech Transformation in Agriculture

Nanotechnology may support "precision farming," the application of information technologies applied to the management of commercial agriculture. Precision farming's enabling technologies include satellite-positioning systems, geographic information systems, and remote sensing devices. By connecting global positioning systems with satellite imaging of fields, farm managers could remotely detect crop pests or evidence of drought. Information about these conditions would trigger an automatic adjustment of pesticide applications or irrigation levels. Dispersed throughout fields, a network of sensors would relay detailed data about crops and the soil. These sensors would need to have nanoscale sensitivity to monitor conditions, such as the presence of plant viruses or the level of soil nutrients.

Other forms of nanotechnology may directly alter agricultural practices. Nanoparticles or nanocapsules could provide a more efficient means to distribute pesticides and fertilizers, reducing the quantities of these chemicals introduced into the environment. Livestock may be identified and tracked through commerce using implanted nanochips. Nanoparticles may deliver growth hormone or vaccines to livestock, or DNA for genetic engineering of plants.

Ultimately, nanotech innovations may enable the agricultural industry to precisely control and improve production. An ability to manipulate molecules may permit the food industry to design food with enhanced function at lower costs. The capability to introduce revolutionary changes in agriculture and food carries risks. Is the federal government prepared to oversee these new developments?

Ahead of the Curve in the Regulation of Agrifood Nanotech

The University of Minnesota's Jennifer Kuzma has emphasized the lack of a comprehensive U.S. oversight policy for nanotechnology, despite the federal government's annual investment of about one billion dollars in nanotech research. Kuzma sees parallels between the regulation of biotechnology and nanotechnology in food and agricultural industries: both technologies have raised debates about whether the government should regulate the process or the product, both technologies offer diverse applications that touch multiple regulatory agencies, and both technologies can be characterized by overlapping or missing regulatory jurisdiction.

As a step toward analyzing regulation of agrifood nanotechnology, Kuzma and Peter VerHage have created a database of nanotechnology food and agriculture-related research funded by the U.S. government. They also examined publicly available information from the U.S. Patent and Trademark Office.

Kuzma and VerHage presented analyses of their data on March 30, 2006, at a program hosted by the Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars and via webcast. During the meeting, Kuzma suggested a bottom-up method for studying regulatory oversight of agrifood nanotech. The process would have three phases: (1) use the research and development database to assess applications of nanotechnology to food, agriculture, and agroecosystems; (2) select individual products to identify risks and benefits; and (3) after assessing particular products, extrapolate to analyze appropriate regulatory or non-regulatory governance systems for agrifood applications. Applying lessons from agbiotech, Kuzma suggested that independent research and safety studies should be performed and made available to the public, and that regulatory agencies should ensure a transparency in the product review and oversight process.

Most of the agrifood applications included in the database, Kuzma and VerHage predict, have a commercial timeframe of 5 to 15 years. David Rejeski, director of the Project on Emerging Nanotechnologies, noted that those concerned about nanotech and food issues enjoy a unique position. "We are ahead of the curve," he said, "and have time to prepare."

The Project on Emerging Nanotechnologies website provides copies of the database, which Kuzma and her colleagues will expand in the future (http://www.nanotechproject.org/index.php?id-11).

Selected Sources

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