PROGRESS AND PLANS OF NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) AGENCIES

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U.S. Department of Agriculture (USDA)[1]

Agriculture Research Service (ARS)

Summary

The USDA Agriculture Research Service has a limited research program in nanotechnology. However, examples of nanotechnology accomplishment for 2019 include the following: (1) nano-detectors to detect as few as 10 enteric bacterial cells in food samples, (2) nanoparticle formulation to supplement human gut microbiota composition, (3) nano-formulations of catfish by-product proteins that generate the highest solids and protein recovery of processing waste, (4) nano-biosensor for detecting fungal neurotoxins in corn and dairy-based foods, (5) nanoscale particles of starch-oleic acid inclusion complexes in films to enhance their biodegradability, and (6) nano-modification of cotton fiber for improved mechanical and thermal properties.

Plans and Priorities by Program Component Area (PCA)

PCA 3. Nanotechnology-Enabled Applications, Devices, and Systems

ARS will be pursuing research and development aimed at the following objectives:

- New five-year research plans to turn biomass into high-value-added nanotechnology-enabled products.[2]
- New five-year research plans to enable nanotechnology food safety methods.[3]

Key Technical Accomplishments

- Non-biodegradable polymer films are an environmental issue. To improve the biodegradability of polymer film, ARS scientists in Peoria, Illinois, have developed nanoscale particles of starch-oleic acid inclusion complexes using steam jet cooking mixtures of high-amylose corn starch and oleic acid and then rapidly cooling the jet-cooked dispersions with ice. Films with good tensile properties were prepared from mixtures of these nanoparticles with styrene-butadiene rubber latex. The advantage of such films containing starch-oleic acid nanoparticles is that the presence of starch in the films will enhance their biodegradability and improve our environment.

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[2] ARS National Program 306: https://www.ars.usda.gov/nutrition-food-safetyquality/product-quality-and-new-uses/

[3] ARS National Program 108: https://www.ars.usda.gov/nutrition-food-safetyquality/food-safety-animal-and-plant-products/

- Rapid nano-detection systems have been developed for pathogenic species from fresh vegetables and fish. This nano-detection method is very sensitive, can detect as few as 10 bacterial cells in a food sample, and can be adopted by the food industry easily.
- Antimicrobial resistance can be developed in fish production systems when synthetic antibiotics are used. It was found that nanoparticles of trans-cinnamaldehyde supplementation can modify the gut microbiota composition in a positive direction by increasing the abundance of beneficial bacteria and serve as a promising alternative to antibiotics for use in aquaculture. In addition, fresh fish by-products, a mixture of heads and frames, contain protein that can be extracted to produce value-added protein. Nanoparticle sizing of this waste by-product, produced in the laboratory, yielded the highest solids and protein recovery.
- Gut microbiota and short-chain fatty acids can be affected by legume type and nano-processing. New findings contributed to the new understanding of the potential gut health benefit of beans as affected by the consumption of different types of legumes and by nano-processing methods.
- A novel nano-biosensor has been developed for detecting fungal toxins in corn and camembert cheese. Cyclopiazonic acid is a naturally occurring neurotoxin that is produced by certain fungi that can infest a variety of commodities and foods. This toxin can be produced by some of the same fungi that produce the more widely known aflatoxins, and the two groups of toxins have been shown to frequently occur together in corn. Cyclopiazonic acid has also been found at significant levels in certain cheeses, such as camembert, that are deliberately molded. ARS developed a nano-bioprocessor method to screen for cyclopiazonic acid in corn and in camembert cheese. The novel nano-biosensor technology uses imaging surface plasmon resonance (iSPR). The assay can be used as a tool to quickly determine whether this toxin is present in corn or in camembert cheese.