Knowing Nanotech Is Knowing the Future of Food and Nutrition

Rao Ivaturi, PhD, remembers his childhood fascination with the 1966 science fiction film *Fantastic Voyage*.

"That was a very smart film," he said of the plot, recalling the team of scientists who miniaturized themselves and a submarine to perform microscopic surgery within the blood cells of a comatose human. "In some ways, that's what's going on today."

Forty-three years later, the Indiana State University professor of nutrition science is directing his graduate students down the same microscopic path, into the very depths of human life he once saw on the big screen—down to the size of a nanometer.

A nanometer is a measurement defined as one-billionth of a meter, even more microscopic than the millionth of a meter known as a micrometer. Consider that the average dust mite is about 200 micrometers in diameter and red blood cells range between 7 and 8 micrometers. DNA, on the other hand, measures between 2 and 2.5 nanometers in diameter. The spacing between silicon atoms is about .078 of a nanometer.

"That's astounding if you think of it," Ivaturi said, pointing to graphical illustrations of theoretical models, all designed to help the human brain comprehend the measurement of its own DNA, measured in nanos, which are comparable to marbles next to Earth.

Thus, the term *nanotechnology* refers to any usage of or technological development at the atomic, molecular, or macromolecular range between 1 and 100 nanometers. The field is as broad as it is emergent, impacting the research of everything from material science to medicine to food science, and offering revolutionary promise in each.

Ivaturi described microemulisons which, designed with the same technology changing the landscape of cancer research, could alter the way people achieve their dietary nutritional requirements. New food packaging systems designed to detect spoilage or disease and coated nutrients designed to bypass cellular barriers are all on the research lists for scientists and their students. And with billions of dollars available for research, the work initially begun within the material sciences during the 1950s is moving at a rapid pace in all directions.

Yet when it comes to nanotechnology, the general public seems to know a nano's worth, if anything at all.

GOVERNMENTS AND PUBLIC BOTH WANT MORE INFORMATION

According to a nationwide survey of 1,003 adults conducted in August of 2008 by Peter D. Hart Research Associates (1), 49% of the participants reported knowing "nothing at all" about nanotechnology, compared to 26% who reportedly knew "a little," with 1% "not sure."

Based on initial impressions, 48% reported being unsure whether the benefits of such technology would outweigh the risks, compared to 20% who felt the benefits would indeed be stronger. Seven percent reported the risks are greater than the potential rewards.

Overall, 12% reported they would use food storage containers enhanced with nanotechnologies, compared to 73% who said they need more information. And when it came to actually purchasing enhanced food, only 7% said they would buy consumer products enhanced by nanotechnology, while 29% said they would definitely not, and 62% need more information.

To Ivaturi, these polling data simply confirm his initial belief that the general public is not knowledgeable of the field. But for his students, future dietitians and food scientists, nanotechnology is to the future of their field as the personal computer was computer technologists in the past.

Ivaturi, who designs dietary modeling software via his Web site, www.webdietitian.com, noted the days of crunching numbers in notebooks, all by hand. Even 20 years ago, a computer might fill an entire room, shrinking down each year until in 2009 many sub-laptops are more powerful than full-size desktops. The same concept of maximizing power while minimizing size applies to the nutritional structure of food and medicine, and it's a future the students of today will know as the status quo within their lifetimes.

But as of yet, regulatory agencies are as wary of the new technology as the publics they service.

"There is no position paper yet that I'm aware of," Ivaturi said of the US Food and Drug Administration (FDA) and the National Institute of Health's stances on altering nutrients at a structural level.

According to an article published by Bugusu and colleagues in the May 2009 issue of *Food Technology*, (2) the FDA is at present still reviewing information obtained from its Nanotechnology Task Force during a February 2008 public forum. The Task Force released a report in 2007 raising a number of questions with regard to the safety of food products made using nanotechnology, and whether the agency's structure could regulate the development of nano-size ingredients. The conclusion of that report was that the agency would be able to successfully regulate the changes in industry, but that case-by-case management would often be required.

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Since the term *nanotechnology* does not refer to any one individual product or process, each new development will likely be judged on its own merits. Industry is encouraged to approach the agency before moving too far into production, same as with other advances.

Health Canada and the Council of Canadian Academies is taking a similar stance in its confidence that regulatory management can occur, but acknowledging that long-term research is unavailable (2).

THE RISKS

"The problem is we have no long-term studies," Ivaturi said, so the question of impact is left wide open.

As part of its 2007 strategic plan, the National Nanotechnology Initiative notes the prediction of toxicity as one on a list of 10 areas to research (3). According to Ivaturi, by redesigning the method in which nutrients, such as iron, are ingested, one could alter the daily requirements needed for human development. However, iron can be lethal in improper doses and, when altered at a sub-atomic level, or administered in a manner that accelerates the body's acceptance, the toxicity has yet to be determined. Some lipid-soluble vitamins can also be toxic if absorption occurs too rapidly or completely, and this is at the heart of nanotechnology's promise.

According to a study conducted by Martin Philbert, PhD, professor of toxicology at the University of Michigan School of Public Health and senior associate dean for Research, coating biocompatible materials significantly reduces toxicity. Philbert also cites studies at Rice University where individualized carbon nanotubes were injected into the bloodstream of rabbits and allowed to circulate for more than an hour before removal by the liver with no adverse health effects found.

Ivaturi discussed the ability to coat proteins with a layer of fat, enabling a smooth transition through a cell's membrane and into the nucleus. The timing and size of such nutrient absorption would obviously be much different administered in this direct a manner, and the question of how much and how often is still up in the air, he said.

The FDA is handling new products on a case-by-case basis under the same guidelines used for traditional products, but meanwhile, testing is underway (2).

The National Nanotechnology Initiative, a coalition of 40 federal agencies and corporations, are accessing grants and private sector funding to determine just how much promise is out there. According to the National Nanotechnology Initiative, federal funding for nanotechnology has increased from $464 million in 2001 to about $1.5 billion for 2009 (4). The National Science Foundation has estimated that 2 million workers will be needed to support global research in this field within 15 years (4).

AVAILABLE ON A WEB SITE NEAR YOU

Concerns notwithstanding, numerous products are being marketed under

the banner of nanotechnology. As with most dietary supplements, the phrase noting that FDA approval has not been offered accompanies most products.

One company offers a drink mix marketed as a dietary supplement, reporting to offer up to 10 servings of fruits and vegetables with each scoop. The ingredient list includes, among other ingredients, barley grass juice powder to plant-based-alpha amylase, bromelain, cellulase, galactosidase, glucoamylase, hemicellulase, lipase, papain, marigold extract, milk thistle, cinnamon extract, green tea, and decaffeinated white tea. According to company information, the product uses "nanotechnology" to make the fruits and vegetables more powerful. Currently this product is available only online, and the company's Web site notes that its statements have not yet been evaluated by the FDA.

Another company offers restaurants a catalytic device which conditions frying-oil through the use of nanotechnology. By catalytically inhibiting the thermal polymerization of frying oil, the product promises to slow the oil's deterioration, thus preserving its freshness and lengthening its use. The result, according to company literature, is crispier fries, higher food quality, and reduced oil and disposal costs.

A foreign company founded by faculty of a university works with producers of nutritional supplements designed with nano-sized, self-assembled liquid structures related to vehicles used in pharmaceuticals. Its investors include suppliers of food products ranging from margarine to edible oils. Vehicles for nutrient delivery are described in company literature as expanded micelles sized at 30 nanometers, termed *fortifying nano-vehicles*. Nutrients have improved bioavailability and solubilization due to the large interfacial area each vehicle provides, lowering the necessary dosage and cost.

One of the nutrients targeted by this company is vitamin D, which is difficult to fortify in low-fat dairy products do to its lack of water solubility. By using the nano-vehicle, this company offers to break this barrier and fortify reduced-fat dairy products, thus ensuring the body's reception of the vitamin. The company is also developing mechanisms for the delivery of lutein, lycopene, phytosterol, and vitamin E.

"There are a lot of nano products out there that call themselves 'nano,'" Ivaturi said, describing brands of "Nano-Tea."

Tea is believed to contain catechins, a chemical with antioxidant properties, he explained. Generally, green tea has more catechins than others, but by increasing the bio-availability of the chemical, one could theoretically create a more powerful version. Similar opportunities are possible with the amino acid sequence in beef protein as well as lycopene content of tomatoes.

"Where is the potential? The potential is everywhere," he said, adding that just enough awareness of nanotechnology is available that some companies are taking advantage of the marketing capability.

WORK STILL ADVANCING

That the public lacks awareness, and companies are advancing marketing plans based on this, might be related to the scope of nanotechnology. Since all matter is comprised of subatomic particles, the ability to manipulate these avails itself to the advance of nearly all scientific endeavors. From material science to medicine, the push for improved quality is taking research smaller faster.

According to Ivaturi, food science is just now taking advantage of the new technology. One area of particular interest is the use of protein molecules as target-recognition groups which could act as biosensors in food packaging. Another area that excites Ivaturi is nanoemulsions. Emulsions are mixtures of liquids which tend to repel one another, such as oil and water. According to a Scientific Status Summary published in the November 2006 issue of *Food Technology* (5), nanoemulsions measure 500 nm or less and can encapsulate functional ingredients within their droplets, facilitating a reduction in chemical degradation.

Similarly, nanolaminates are layers of food-grade film between 1 and 100 nm per layer. According to the summary, edible nanolaminates can be constructed from polysaccharides, proteins, and lipids and serve as barriers against oxygen and carbon dioxide. And while such layers can ultimately reduce or prevent spoilage, it is the long-term impact of human consumption that requires more research.

But in the end, concerns based in lack of knowledge will not halt these developments. Ivaturi said the food and nutrition professionals of tomorrow see this as normal course of study in today's classrooms.

"You should not fear technology," Ivaturi said, noting it is a tool at the disposal of the human mind which created it.

References

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ADDITIONAL RESOURCES

For more information on nanotechnology and dietetics, please see these articles in the *Journal*:

- Nickols-Richardson SM. Nanotechnology: Implications for food and nutrition professionals. *J Am Diet Assoc*. 2007;107:1494-1497.
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