EATING NANO

Processed Foods and Packaging Already Contain Nanoparticles – Some of Which Could Be Harmful to Our Health

By Brita Belli

Our food supply is not nearly as safety-tested as we would like to believe. True, things are not as dire as they were in the early 20th century when Upton Sinclair's *The Jungle* exposed the filth of the meatpacking industry, leading to reforms that included the founding of an agency that would become the U.S. Food and Drug Administration (FDA). But there are still unsettling gaps in what we know about the food and food packaging that is already sitting on supermarket shelves.

Unbeknownst to just about everyone, nanoparticles made a quiet entrance into the nation's food supply at least a decade ago. Nanoparticles are materials that are microscopic – significantly smaller than a red blood cell; and tens of thousands of times smaller than the width of a human hair. These particles can help deliver nutrients, ensure longer freshness of food, act as thickening agents, or enhance taste or flavor. The problem is, scientists are still determining the health and environmental impact of these tiny particles, even as industry is forging ahead.

"At the moment, there is not much information available on the topic of ingested nanoparticles and human health," says Birgit Gaiser, PhD, a postdoctoral research fellow at Heriot-Watt University in the UK. "Some nanoparticles are present in the human diet, for example titanium dioxide in food products and cosmetics, and silver, which is sold as a nutritional supplement. There is evidence that a small percentage of these particles, or particle components like silver ions which can be released in stomach acid, can move on from the intestinal tract into the blood, and reach other organs. This is why we believe it is important to assess the risk of even small amounts of particles in the human body and ensure that the types of particles present in the human diet and cosmetics, as well as the amounts ingested, can be considered safe."

The FDA has been slow to catch up. In fact, the agency doesn't even track which foods contain nanoparticles. Following is a recent e-mail exchange with Sebastian Cianci, a spokesperson at the FDA:

> **E Magazine: What can you tell me about the prevalence of nanomaterials in our food supply?**
>
> **Sebastian Cianci:** FDA does not have a list of food products that contain nanomaterials.
>
> **E: Where are nanomaterials most often found within food products? In colorings or additives?**

S.C.: FDA does not maintain a list of food products that contain nanomaterials, so we cannot reliably answer this question.

Now With Extra Nano

There is no doubt that nanoparticles are in the food supply and have been for years. Recent research found that foods with caramelized sugar, including bread and corn flakes, contain carbon nanoparticles. Many nutritional supplements – or "nanoceuticals"– come equipped with copper, silver, or iron nanoparticles. Nanoparticles can be used to purify water, as anticaking and gelatin-forming agents and in packaging to protect against UV light, prevent the growth of microbes, or detect contamination. Titanium dioxide is added to a huge swath of products in nano form, including paints, paper, and plastics, but also lends white pigment to most toothpastes and many processed foods, including Mentos, Trident, and Dentyne gum, M&Ms, Betty Crocker Whipped Cream Frosting, Jello Banana Cream Pudding, Vanilla Milkshake Pop Tarts, and Nestlé Original Coffee Creamer. The aforementioned products were featured in a report in February 2012, in the journal *Environmental Science & Technology*, which concluded that each of us likely consumes some amount of titanium dioxide (TiO2) nanoparticles each day, and children under 10 likely consume the greatest amounts (around 1-2 mg TiO2 per kilogram body weight per day) due to their higher intake of frosted foods, candy, gum, and other sweets.

Then there are the nanoparticles that are not intended to enter the food supply, but because of their miniscule size slip through wastewater treatment in particle or dissolved form and take up residence in the biosolids created at the end of the wastewater treatment process. These biosolids are later applied to fields as fertilizer for their nitrogen and phosphorus content. In August 2012, a team of researchers led by scientists at UC Santa Barbara looked at the impact of two nanoparticles on soybean crops. They discovered that soybean plants absorbed zinc oxide nanoparticles from sunscreens, cosmetics, and lotions into their leaves, stems, and beans. It was certain these particles were entering the food supply, but unclear what impact they might be having. The researchers admitted that these nanomaterials in the wastewater treatment plant systems could be measured, but aren't.

Besides the foods themselves, dietary exposure to nanoparticles is also happening through food packaging. The European Institute for Health and Consumer Protection reports that the market for nanomaterials in food packaging is expected to reach $20 billion by 2020 (the nanotech industry as a whole is expected to reach $1 trillion by 2015). There is nanoclay, used by beverage companies to prevent permeation of gases from plastic bottles; nanoaluminum, used to improve the functioning of aluminum foil, making it better able to reflect heat and prevent sticking; nanosilver, used for its antibacterial properties in some food containers; and nanotitanium, which provides filters for home fridges. It's even likely that we regularly ingest silver nanoparticles that are shed from our forks, spoons, and knives, according to a 2011 study in the journal *ACS Nano*.

"We know that there's nanosilver in food wrapping and food packaging," says Jennifer Sass, a senior scientist with the Natural Resources Defense Council. "That nanosilver

releases ions, so those ions could be getting into the food. The ions are toxic, they are the antimicrobial part of the silver."

From the government's perspective, nano forms of silver, iron, or titanium are no different, fundamentally, from their scaled-up counterparts which have already been safety tested, so the agency has ushered the particles into the food supply under the Generally Recognized as Safe provision. In other words, companies are not required to disclose these tiny ingredients, hence the FDA's ignorance on where they are hiding. But as the environmental organization Friends of the Earth notes on their website: "The properties of nanoparticles are not governed by the same physical laws as larger particles, but by quantum mechanics. The physical and chemical properties of nanoparticles – for example, color, solubility, strength, chemical reactivity, and toxicity – can therefore be quite different from those of larger particles of the same substance."

The FDA issued a draft guidance for manufacturers in the food industry, in April 2012, advising them to consider where using nanotechnology will affect the identity or safety of the food substance, which could lead to an acknowledgment on the product label, but only at the manufacturer's discretion.

"Under existing statutory and regulatory provisions, manufacturers are able to voluntarily include information about the use of nanomaterials or nanotechnology in the labeling of products," Cianci wrote to E, "where such information presented in the context of the entire label or labeling is not false or misleading and does not violate other labeling requirements."

Companies, Consumers Left Clueless

Before companies consider labeling food products as nano-containing (and with all the consumer skittishness about changes to the food supply, who would?), it would probably help if they knew what was in them. In many cases, particularly when it comes to food packaging, they don't. The environmental and shareholder advocacy organization As You Sow released a report in 2011 on nanomaterials in food and food packaging in which they interviewed five food giants – Kraft Foods, Yum! Brands, Pepsico, McDonald's, and Whole Foods – in hopes to learn how these companies were using or planning to use nanomaterials. In many cases, says As You Sow's Senior Strategist Michael Passoff, "They had to go back to their supply chains and check. It's hard for the companies to know. The manufacturers of nanofood or nanopackaging are not required to identify it anywhere."

In speaking with representatives from these companies, however, Passoff says most were taking a cautious approach. They didn't want to risk a negative association with a technology that has potentially harmful health and environmental impacts. "They all admit that 'We're watching the technology, if it's proven safe, then we'll use it in the future, but right now we're not using it," Passoff says. Underscoring that uncertainty, McDonald's put the following disclaimer on its website: "Given the current uncertainty related to potential impacts of nano-engineered materials, McDonald's does not currently support the use by suppliers of nano-engineered materials in the production of any of our food, packaging, and toys."

But McDonald's is the exception when it comes to informing the public. The Woodrow Wilson International Center for Scholars' Project on Emerging Nanotechnologies may be the only place trying to keep tabs on which products – including food products and supplements – contain nanomaterials, but its 1,000-plus manufacturer-identified inventory is woefully incomplete, particularly when it comes to food. Just five products are listed under foods, and none of them would create much of a stir: Among U.S. products, just a Saeco Primea Ring Automatic Espresso Maker (which contains a silver ion coating) and Nanoceuticals Slim Shake Chocolate are identified. "They haven't really updated that for at least a year and a half," says Passoff. "And the one item on there that we actually looked at (a McDonald's milkshake, which has since been removed) turned out to be wrong."

Unknown Health Consequences

While the government remains hands off, consumer health and environmental groups, including As You Sow, NRDC, and Friends of the Earth, are warning of the mounting evidence suggesting that nanoparticles, because of their small size, can cause harm when inhaled or ingested. In 2011, researchers discovered that silver nanoparticles, when inhaled, cause lung toxicity or inflammation in exposed mice. Similarly, inhaled copper nanoparticles increased the risk of pulmonary infections in mice. Carbon nanotubes, used in super-strong plastics and for computer chips, have presented a particular worry, when research found in 2008 that the particles can damage lungs much like asbestos, which the particles resemble in shape and size. The pointy microscopic cylinders can lodge in lungs and could give rise, like inhaled asbestos fibers, to cancer.

Of course, such findings pertain more to consumer products – like clothing treated with antimicrobial silver particles – than foods, but eating nanoparticles carries its own consequences. It's a swift pathway from inhalation to the brain (nanoparticles are small enough to bypass the blood-brain barrier), but ingestion, too, can carry particles into the bloodstream where they can travel and accumulate throughout the body. A guide on the American Society of Safety Engineers' website sheds chilling light on the potential dangers of nanoparticle ingestion. They write: "Nanoparticles may be ingested through drinking water, food additives, atmospheric dust on food, toothpaste, and dental fillings and implants. Ingested nanoparticles can then be absorbed through "Peyer's Plaques" or small nodules in intestinal tissue that are part of the immune defense system. If nanoparticles enter the digestive system and proceed into the bloodstream, they could move throughout the body and cause damage." They continue: "Nanoparticles may also accumulate in certain organs, disrupt and impair biological, structural, and metabolic processes and weaken the immune system.

Some of the impacts of chronic exposure to nanoparticles appear to be more subtle. A Cornell research team led by Gretchen Mahler, PhD, found that when chickens consumed large doses of polystyrene nanoparticles, approved for human consumption, it had two opposite effects. When exposure was acute (i.e., a lot given in a short amount of time), it blocked the animals' ability to absorb iron. When exposure was chronic (i.e., a little over a longer period of time), it resulted in increased intestinal villi and an increased rate of iron absorption. Chickens absorb iron much like humans, and although Mahler would not speculate if a similar effect may be happening in humans, she admits that her research suggests nanoparticles can induce changes that may not be obvious. "Nanoparticle

exposure, even exposure to nanoparticles that are generally considered safe, can have unintended physiological consequences," Mahler says. "Nanoparticle-based materials are being developed for many different applications and the human response, especially the more subtle effects related to chronic exposure, is not always known."

And Mahler notes that each nanomaterial is unique in the way it interacts with the human body. "The nanomaterials that are being developed all have very different reactivity with human tissues," she says. "This means that you can't apply results with one type of nanoparticle to all other nanoparticles – you have to test them all individually."

Gaiser, whose research has looked at the impact of various nanoparticles – including nanosilver – is part of a team of researchers developing InLiveTox, a non-animal (or "in vitro") model for testing nanoparticles being funded by the E.U. There are so many nanomaterials in need of testing, and tens of thousands of chemicals overall that have been approved in the U.S. despite a lack of basic toxicity testing, that the classic animal testing model is now seen as too time-consuming, and too cruel, to be effective. As one article in *ACS Nano* noted, our sluggish testing method "leaves us exposed to new toxicological scares on a continuous basis. While admittedly it is impossible to perform risk assessment and management without *in vivo* (whole, living organism) toxicological data," the article continues, "it is becoming clear that animal testing may not provide the best test method when confronted with thousands of new chemicals and nanomaterials."

InLiveTox combines human cell models of the intestine, blood vessels, and liver to simulate the actions of nanoparticles as they travel across these layers, from bloodstream to organs. "The cells at the different steps of the combined system can then be analyzed as a whole or separately for damage by particles, inflammation and other effects, and they can interact with each other, which makes the InLiveTox system more lifelike than standard models," says Gaiser. "This type of experiment is extremely important, because thousands of different nanomaterials are already in use with more being developed constantly, and it would be unethical to test every single particle using animal models."

Science has already shown that nanoparticles, once ingested, can be taken up by the intestinal tract and, depending on their size, pass into the lymph nodes, affecting the immune system, or into the capillaries, where they can settle in various organs. For this reason, an article in the *Journal of Nanobiotechnology* in 2004 cautions that "For those nanoparticles designed to stabilize food or to deliver drug via intestinal uptake, other, more demanding, rules exist and should be followed before marketing these compounds."

Approach With Caution

In the absence of specific regulations, the onus remains on food producers to figure out if they are unwittingly packaging food in nano-containing wrappings, proceed with caution in including nanomaterials in their products, and keep the public informed with clear labeling. A 2011 report from As You Sow provides companies with a series of steps they can take to achieve transparency – by insisting that their suppliers provide information on nanomaterials and related safety data and by participating in voluntary government reporting and keeping the public up to date on all safety testing information. In many ways, adhering to the provided framework will prevent future "toxicological scares," which can damage a company's reputation and bottom line, from happening.

“Kraft has its own scientists,” says Passoff. “But other companies don’t have an extensive network, so what questions do you need to ask to know ‘Is it in our supply chain?’ ‘Is it safe?’ ‘What are the risks and benefits from it?’ ‘Why are we using it?’ ‘Why do our suppliers want to use it?’ That’s how the framework came up. It was really what companies should ask their suppliers regarding the safety of products containing nanomaterials. So businesses can make more informed decisions.” The organization is also in the process of surveying hundreds of companies to compile their own database of those using nanomaterials. In the meantime, shoppers with iPhones can download the findNano app, but it draws its information from the Woodrow Wilson Center’s Consumer Products Inventory, which won’t reveal much, particularly at the grocery store.

At the NRDC, Sass suggests that the FDA needs to move beyond collecting data and into more serious regulation of all chemicals and nanoparticles. The Safe Chemicals Act, which passed the Senate Committee on the Environment and Public Works in July 2012 and would insist on mandatory safety testing for all approved chemicals, does not specifically mention nano. But it alludes to it. The bill would grant the Environmental Protection Agency Administrator the ability to determine whether a chemical substance is being used in a different-than-normal manner and should be considered a distinct substance. If the chemical [i.e., nanoparticle] is determined to be separate, it would be subject to its own safety testing.

While not explicit, that portion of the law would provide some method of controlling the spread of the most suspect nanoparticles. “We’re just trying to get them [nanoparticles] to be considered as unique from conventional, to be regulated better,” says Sass. “We think chemicals should be regulated better.”

And safety studies of nanoparticles, says Mahler, need to take into account the long-term, smaller exposures happening over a lifetime. “Safety studies should involve chronic exposure results,” she says, “and should look at the more subtle, sublethal effects of nanoparticle consumption.”