An Overview of Opportunities and Challenges of Food Nanoscience/Technology

BIOECONOMIA ARGENTINA 2014
5 y 6 de junio de 2014
Tattersall (Av. del Libertador 4595) Buenos Aires, Argentina

Rickey Y. Yada, Ph.D.

Professor

Canada Research Chair in Food Protein Structure
Scientific Director

Advanced Foods and Materials Canada (AFM Canada)

Department of Food Science
University of Guelph
Guelph, Ontario N1G 2W1







Nano, nano everywhere!



Nanotechnology Organisations – Argentina

Argentina has a number of organisations and networks committed to promoting nanoscience and exploring the challenges and future of nanotechnology. The following are key nanotechnology-related organisations in Argentina:

<u>Fundacion Argentina De Nanotecnologia (FAN)</u> - Its main responsibility is to promote domestic nanobased production for domestic consumption and to integrate local industry into international markets. Since early 2010 the FAN carried out a nanotechnology program for industry and society, with over 20 meetings held across the country.

Instituto De Nanociencia y Nanotecnolgia (Institute of Nanoscience and Nanotechnology) - The Institute of Nanoscience and Nanotechnology includes scientists from the Comisión Nacional de Energia Atómica (CNEA) (National Atomic Energy Commission) and is a center of excellence in Argentina which includes all disciplines of science and technology production in the area of nanotechnology.

<u>Centro Argentino De Ingenieros (CAI) (Argentine Center of Engineers)</u> - The Argentine Center of Engineers is a civil non-profit made up of professionals from all branches of engineering, architecture, surveying, allied professionals and institutions consistent with the goals of the Center and companies that wish to collaborate in raising the standards of engineering, for the good of the nation.

<u>Argentine-Brazilian Center for Nanoscience and Nanotechnology</u> - It is the first bi national nanotechnology organization in Argentina, aimed at promoting science and technology and increasing productivity between the two countries. Formed in November 2005, it promotes new research facilities, knowledge sharing and human resource training.

<u>Laboratoire International Franco-Argentin en Nanosciences (LIFAN)</u> - It is an International Associated Laboratory in Nanoscience and nanotechnologies formed to boost collaboration between the two countries, thereby enabling them to face international competition, attract PhD students or post-doctorate students, and to improve technical resources.

Nanotechnology Companies - Argentina

The major nanotechnology-based companies in Argentina are listed below along with a brief introduction to each of them:

<u>Nanotek</u> - Nanotek is a Research and Development Company with nanotechnology as its focus. The vision of Nanotek is to be a world leader using nanotechnology to improve the quality of life. Their mission is to focus on researching, manufacturing and marketing products and services for the developing nanotechnology market. Their nano products can be used in numerous fields such as mining, roads, textiles, health materials etc.

<u>Nanotec Latina</u> - Nanotec Latina S.H. represents worldwide nanotechnology companies in two key markets: Latin America and the U.S.A.. Nanotec Latina S.H. is a demand-driven and import-oriented brokerage company, aimed at making future and existing nanotechnology ideas and products available to consumers throughout the mentioned markets in Spanish language.

Nanotechnology Education and Research

Argentina has a couple of universities offering research and educational opportunities in nanotechnology. They are as follows:

The Research Institute of Theoretical and Applied Physical Chemistry (Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas INIFTA) – INIFTA is a theoretical and applied physical chemistry research institute sited on the premises of the Universidad Nacional de La Plata, (UNLP), La Plata, Argentina. The nanotechnology based research activities include the following areas:

Development of New Methods for Surface Nanostructuring

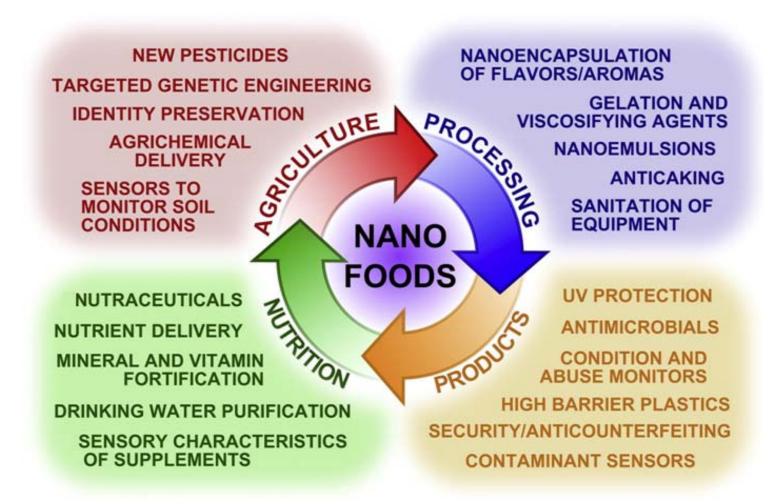
Surface Science and Nanoscience

Experimental Studies Based on Synchrotron Light Techniques.

Nanostructured Systems: Basic Structural Aspects and Applications.

National University of Quilmes - offers a nanomedicine program.

Nano in Agri-Food



Challenge – Food applications

- Definitions
- Regulations
- Education
- Consumer attitude/acceptance
- Moving from concept to consumer product/technology

Defining Nanotech

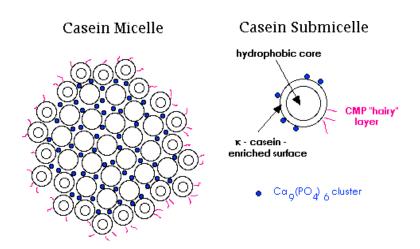
- Two principal parts to defining what is to be considered nanotechnology:
- (i) Scale and (ii) Uniqueness/novelty
- Nanotechnology is the understanding and control of matter....
 - □ (i) →... at dimensions between approximately 1 nm to 100 nm
 - □ (ii) → ... where unique phenomena enable novel applications

When talking about nanoscience/technology are all objects/particles synthesized (Engineered Nano Materials)?

NO!!



Scientific American Jan. 18 2008



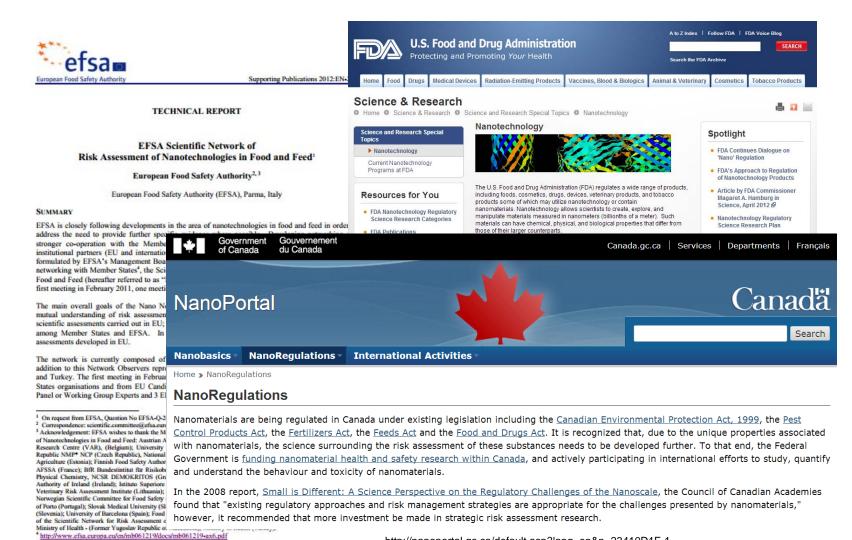
P. Walstra and R. Jenness In: P. Walstra and R. Jenness, Editors, *Dairy chemistry and physics*, Wiley, New York (1984)

http://www.foodscience.uoguelph.ca/deicon/casein.html

Regulatory Challenges

 Lack of harmonization of definitions and guidelines among various regulatory agencies

Regulatory Challenges

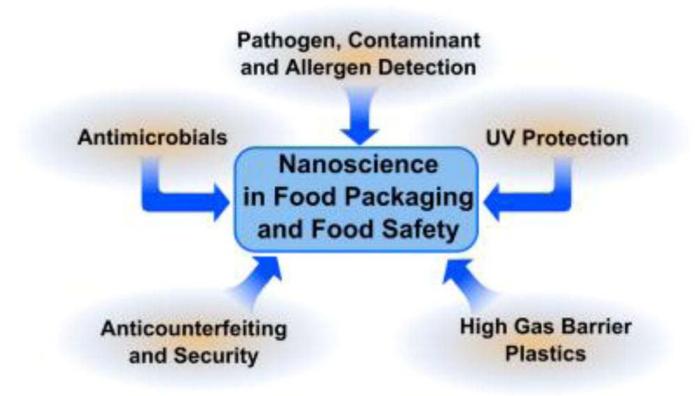


Suggested citation: European Food Safety Authority; EFSA Scientific Network for Risk Assessment of Nanotechnologies in Food and Feed, Supporting Publications 2012; EN-246, [10 pp.]. Available online: www.efsa.europa.eu/publications

© European Food Safety Authority, 2012

http://nanoportal.gc.ca/default.asp?lang=en&n=23410D1F-1

Nano – Food Packaging



Nano-Sensors

- Potential Applications:
 - Pathogen detection (bacteria, viruses)
 - Toxin and pesticide detection
 - Spoilage detection
 - Authenticity and traceability
 - Quality control

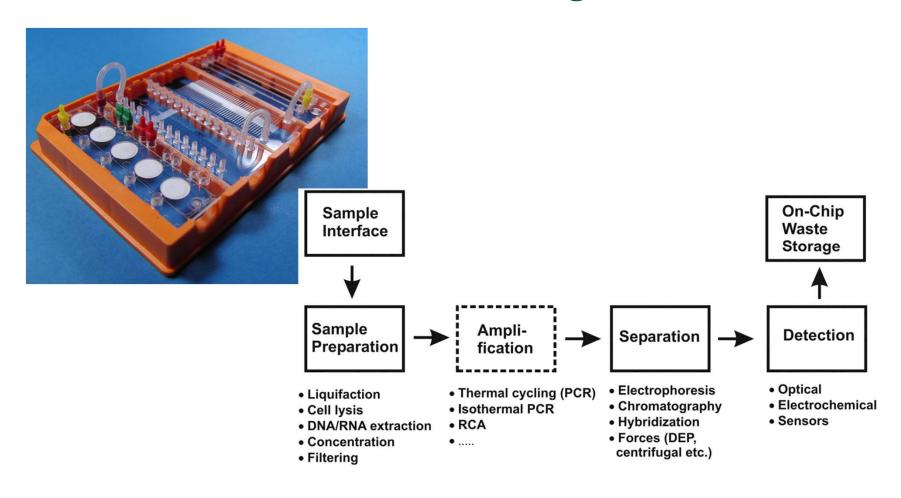
Nano-Sensors

- UV activated, oxygen sensitive, colored ink based on titanium dioxide.
- Changes color in presence/absence of oxygen.

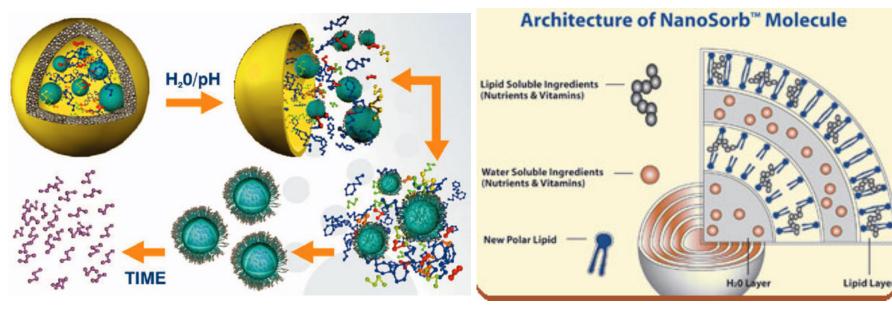


Photographs of oxygen indicator ink printed on a MAPed food package. Left: Before UV activation. Middle: After UV activation. Right: On opening the package. (Photographs: David Hazafy, University of Strathclyde)

Microfluidic SERS for "Lab-on-a-Chip" Device of Detection of Foodborne Pathogen



Nanoencapsulation - nanoemulsions



Shefer, A. (2005) www.foodtech-international.com/papers/images/application-nano/fig1

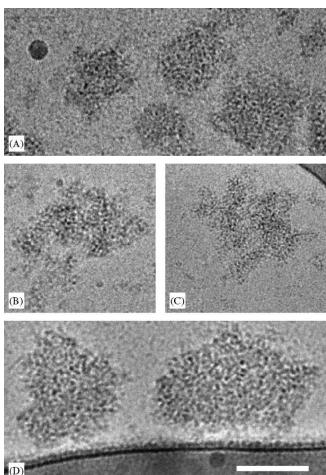
http://nanogreensinfo.com

- Functional ingredients are essential components in many foods
 - e.g., vitamins, colours, flavours, preservatives, antimicrobials, etc.)
- Usually need some sort of delivery system to optimize activity.
- Pay load substantially decreased

Casein nanoparticles as nano-vehicles

Casein micelles

- Nano-capsules created by nature to deliver nutrients (calcium, phosphate, protein) to the neonate
- Natural self-assembly tendency of bovine caseins
- Morphology and average diameter of reassembled micelles similar to those naturally occurring
- Useful nano-vehicles for entrapment, protection and delivery of sensitive hydrophobic nutraceuticals within food products, e.g., vitamin D2



Cryo-TEM images of (A) naturally occurring CM in skim milk; (B) and (C) re-assembled CM; (D) D2- re-assembled CM. The bar on the bottom right is 100nm long. (The dark area on the bottom is the perforated carbon film holding the sample.)

Health issues

- Diabetes
- Obesity
- Cardiovascular diseases
- Micronutrient deficiencies

Despite health concerns, it's still hard to resist!

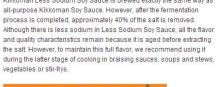


KFC Double Down = 1,740 mg Sodium McDonald's Big Mac = 1,020 mg Sodium Burger King's Whopper = 970 mg Sodium

Recommended Daily Intake = 1200-1500 mg Sodium

Sodium

Home Cooks > Products > Soy Sauce Types > Less Sodium Soy Sauce Less Sodium Soy Sauce Kikkoman Less Sodium Soy Sauce is brewed exactly the same way as vegetables or stir-frys. SOY SAUCE: Less Sodium, More Flavor





Click here to download our tips for reducing sodium in the kitch

Honzukuri Low Salt Miso 26.4 oz

Product Number - 01217 Bin Number - 7002

More Info Nutritional Info

Customer Reviews

Love the flavor of miso Paste, but want a healthier option? This lowsalt miso paste has the miso taste you love with less salt. Perfect for making a savory, healthy miso soup. Check out our other varieties of miso soup and miso paste.

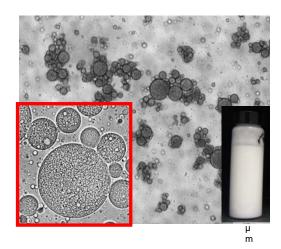
http://www.kikkomanusa.com/homecooks/products/products_hc_details.php._ f=10102&fam=101

http://www.asianfoodgrocer.com/product/honzokuri-low-salt-miso-26-4-oz

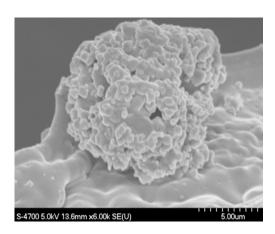
HONZUKURI

Bio-molecular carriers

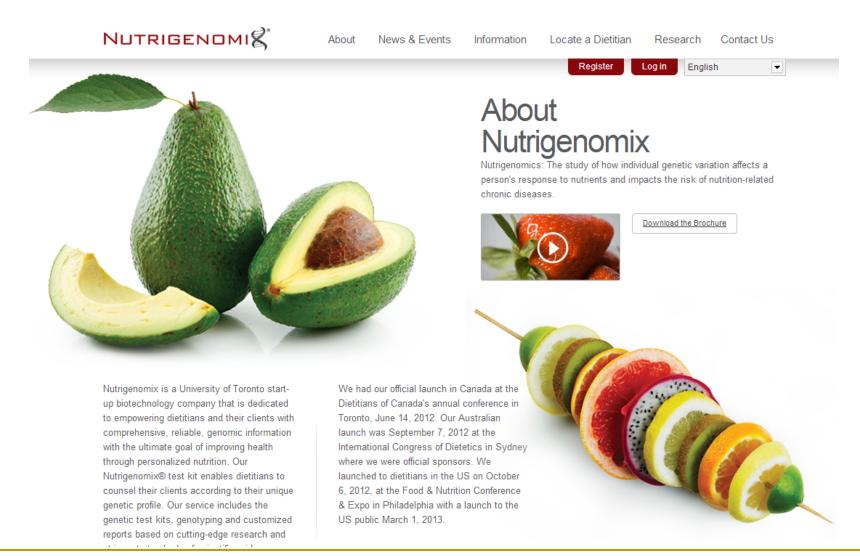
- Double emulsions (W/O/W)
 - Inner phase comprised of nano-sized droplets w/ NaCl.
 - Liquid foods soups



- Biopolymer-based nanoparticles
 - pH-sensitive protein-polysaccharide carriers
 - Proprietary polysaccharide carriers
 - Solid foods cheese

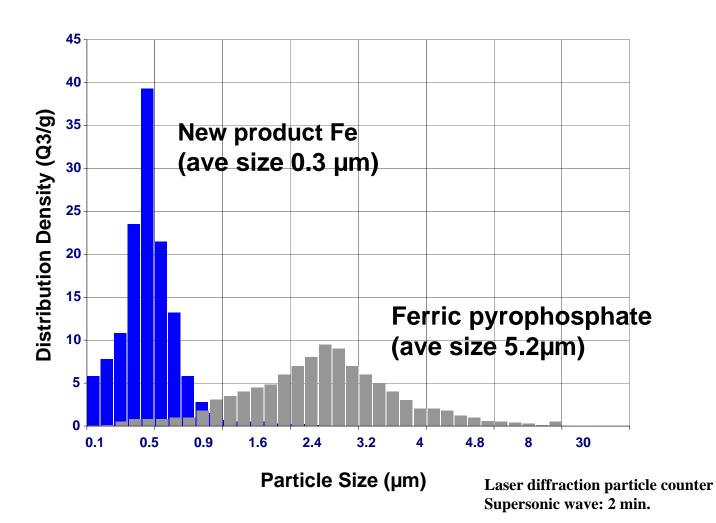


Nutragenomics

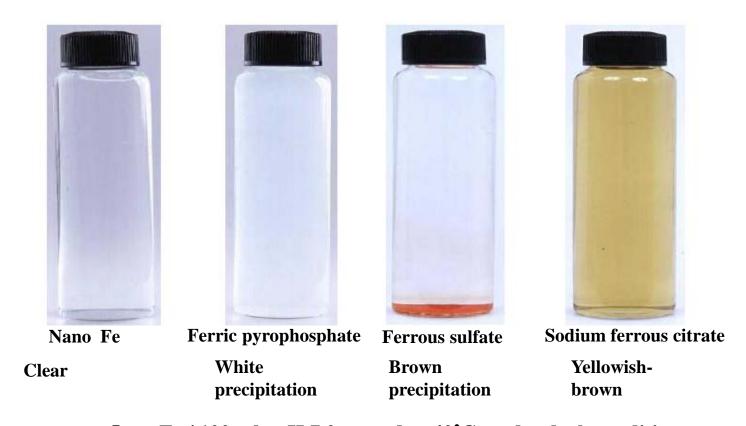


Problems with iron fortification

- Unpleasant taste and color
- Instability, precipitation
- Toxicity, nausea, vomiting, poor appetite, diarrhea and constipation
- Poor bio-availability



Stability of Iron Sources



5 mg Fe / 100 ml, pH 7.0, stored at 40°C under dark conditions Storage time: Nano Fe for 3 months, all others 2 days

Authenticity/Traceability

STUDY I) YOU THOUGHT YOU ORDERED SEA BASS

Fishy business

You say tuna, I say tilapia: DNA testing shows that one-quarter of fish is mislabeled

BY REBECCA DUBE

efore you bite into that fish and chips or spend \$30 on halibut at the supermarket, you may want to take a second look: 25 per cent of fish is mislabelled, according to a University of Guelph study published today that used DNA analysis to determine the true identity of fish sold in Toronto and New York.

One sample sold as tuna turned out to be tilapia; halibut was really hake; and red snapper was, on different occasions, lavender jobfish, Labrador redfish, perch and cod.

"There's not a lot of regulation around fin fish: it's basically been ignored," says study co-author Robert Hanner, associate director for the Canadian Barcode of Life Network and an assistant professor of biology at the University of Guelph.

"Now that we have the tool to do it, we probably have an obligation to start testing."

He and co-author Eugene Wong tested 96 samples of fish from grocery stores, markets and restaurants in New York and Toronto. They analyzed the DNA of each fish and compared it with a global database of species. They intended simply to test the database, which performed well, identifying each piece of fish they found. Discovering so much fish fraud was a surprise. >> SEE 'FISH' PAGE 3

There's not a lot of regulation around fin fish; it's basically been ignored.

Robert Hanner, study co-author



PHOTO ILLUSTRATION/THE GLOBE AND MAIL



Food Safety – Traceability: DNA



Largest-Ever Seafood Fraud Study Has Guelph Ties

February 22, 2013 - News Release

The largest-ever market study on mislabelled seafood now making headlines around the world has roots at the University of Guelph.

DNA analysis showing mislabelling of 33 per cent of fish sold in grocery stores, restaurants and sushi bars in the United States was conducted at the Canadian Centre for DNA Barcoding based in U of G's Biodiversity Institute of Ontario (BIO).

The Guelph centre was commissioned to conduct the testing by Oceana, the largest international oceans advocacy group. Overall, the study found 44 per cent of all retail outlets sold mislabelled fish.

Food Safety – Traceability: DNA –Plant Material - Herbals

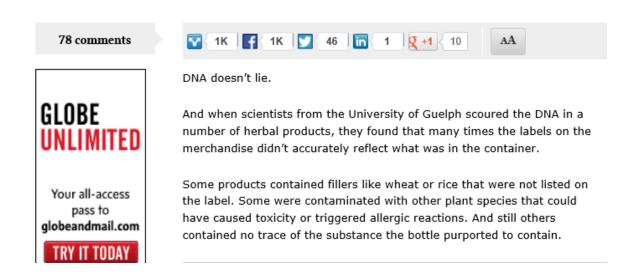
Home » News » National



That herbal supplement may not be what you think it is, scientists find

HELEN BRANSWELL

TORONTO — The Canadian Press Published Friday, Oct. 11 2013, 8:25 AM EDT Last updated Friday, Oct. 11 2013, 8:56 AM EDT



Consumer/Public Issues

- What are some of the issues consumers/public concerned about?
 - Transparency and inclusivity
 - Fear of the unknown
 - Can we guarantee zero risk?
 - Is science static?

How much do consumers really know about nanotechnology?

International Journal of Consumer Studies

International Journal of Consumer Studies ISSN 1470-6423

'Better safe than sorry': consumer perceptions of and deliberations on nanotechnologies

Lucia A. Reisch¹, Gerd Scholl² and Sabine Bietz³

Abstract

Although nanotechnologies are considered key technologies that can drive growthgenerating innovations in well-saturated markets, worldwide investment in nanotechnologies has to date focused largely on technology-related development programmes and little effort has been expended to research associated risks. As a result, even though prior discourses have sensitized western consumers to potential health-related dangers, solid knowledge on, for example, the toxicological and eco-toxicological risks and unintended side effects of nanotechnology are scarce. This paper therefore presents an overview of the current evidence on consumer knowledge and perceptions of nanotechnology and public engagement with it, with a focus on the US, the UK and Germany. Overall, even though survey data suggest that awareness of the term 'nanotechnology' has risen slightly, today's consumers are generally ill informed about its nature and its applications in consumer related products. Hence, based on our analysis of these data, we argue that early political engagement in the nanotechnology issue – for example, consumer policy options that support consumer interest in the marketing of 'nanos' – would facilitate objective public discourse.

Reisch, Lucia A., Gerd Scholl, and Sabine Bietz. "'Better safe than sorry': consumer perceptions of and deliberations on nanotechnologies." *International Journal of Consumer Studies* 35.6 (2011): 644-654.

Undergraduate Students' Risk Perception and Argumentation Concerning Nanomaterials in Consumer Products

Authors: Karlsson, Caroline; Enghag, Margareta; Wester, Misse; Schenk, Linda

Source: Journal of Nano Education, Volume 6, Number 1, June 2014, pp. 50-62(13)

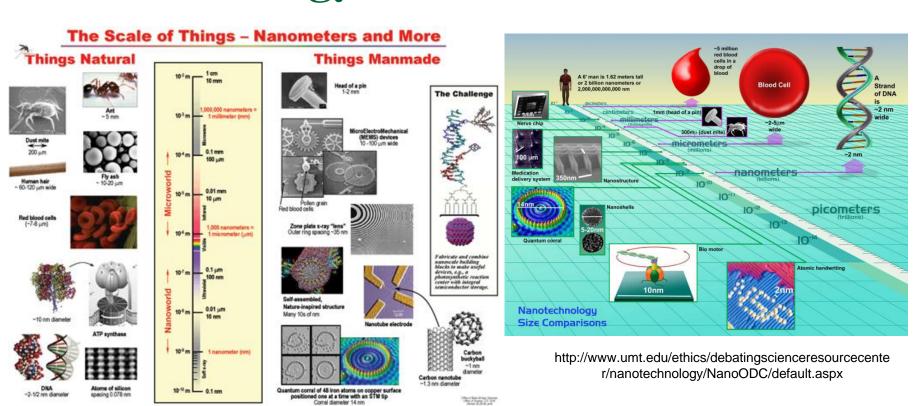
Publisher: American Scientific Publishers

Abstract:

In the present paper we combine two analytical frameworks in order to extend our understanding of how students reason about a socio-scientific issue, namely, nanomaterials in consumer products. Using the results from two focus group discussions including seven students each, we first thematically explored undergraduate engineering students' risk perception. Two main themes were found in this analysis: "Exploring the concept of nanotechnology" and "Handling risks with nanotechnology." Second, we analyzed the nature of students' arguments using the SEE-SEP model, which is a coding scheme based on the subject areas Sociology/Culture, Environment, Economy, Science, Ethics/Morality, and Policy, intertwining the three aspects Knowledge, Values, and Personal experience. According to this analysis, 55% of the participants' arguments were based on values, 25% on knowledge, and 20% on personal experiences. Despite the absence of specific knowledge, however, the students could conduct a complex argumentation about nanomaterials and actively examined the paradox of new opportunities but unresolved risks. The students' reasoning reveals that arguments in favor and arguments against the use of nanomaterials in different products do not cross each other out, but co-exist. The results indicate that the risk perception was influenced to some degree by the area of use, such as skin care products or car treatment. It was also found that when lacking specific knowledge, our participants turned to analogies to other technology developments. Implications for education on nanotechnology are discussed.

http://www.ingentaconnect.com/content/asp/jne/2014/00000006/00000001/art 00006

Helping the public understand nanotechnology



http://www.understandingnano.com/introduction.html

Educating the public, especially the young



National Nanotechnology Initiative

Nanotechnology 101 | Nanotechnology & You | About the NNI | Collaboration & Funding | Publications & Resources

Education | Newsroom | Events

Home | Sitemap | NSET Agencies | Contact Us | Search Nano.gov

For K-12 Students

No matter how old or you are, learning about nanotechnology can be fun and exciting. All around the country, we have found new ways to learn about nanotechnology. There are museum exhibits with hands-on experiments and exhibits, and even if you can't get there, you can watch the experiments and visit the museums online. There are magazines with cool stories and games about nanotechnology. Check out the nanotechnology bus that drives around the country and find out when it's coming to your town. There's even a program to learn about nanotechnology by playing with Legos®!

Here you will see that nanotechnology is not just one thing. It is chemistry, physics, biology and materials science at the molecular level. After all, every one of us is made of atoms!

Check out these links to learn more about the fun and interesting ways you can learn about nanotechnology. (You may need to install the latest version of Flash to play some of the games.)

Nanooze is an online and print science magazine created by Cornell University as part of the education programs of the NNIN--the National Nanotechnology Infrastructure



Students learn about nanoscience and nanotechnology at the NanoDays event hosted by the University of Nebraska-Lincoln. Visit nisenet.org for this year's dates and locations.

Network. It has online games, articles, and a blog, and you can view it in English, Spanish, and Portuguese.

Education

For K-12 Students

For K-12 Teachers

College and Graduate Programs

Associate Degrees, Certificates, & Job Info

Educating the public, especially the young



Science, Philosophy Debates

Is the debate around nanotechnology similar to the debate around genetically modified organisms (GMO)?

In Pursuit of Nanoethics

The International Library of Ethics, Law and Technology Volume 10, 2014, pp 39-57

GM Food and Nanotechnology

Ronald Sandler

Abstract

In matters characterized by a high degree of complexity or uncertainty, such as the social and ethical dimensions of an emerging technology, it is often useful to begin with historical analogies (Steinbruner 2002). In the case of nanotechnology, one of the favored analogs is genetically modified (GM) foods. Even a cursory read of the first generation of social and ethical issues (SEI) literature on nanotechnology reveals that the GM food analogy plays prominently in motivating and framing the discourse, if not the agenda of SEI research. This chapter offers critical reflections on the comparisons between nanotechnology and GM foods. The aim is to identify the respects in which the comparisons are helpful in clarifying and responding to the SEI associated with emerging nanotechnologies, as well as the respects in which the comparisons are unhelpful or misleading. After reviewing several similarities and dissimilarities between the two types of technologies, three potential lessons from the GM food experience for emerging nanotechnologies are evaluated: a lesson on public engagement; a lesson on technological fixes; and a lesson on case by case assessment.

Inequalities in Scientific Understanding: Differentiating Between Factual and Perceived Knowledge Gaps Science Communication 2014, Vol. 36(3) 352–378 © 2014 SAGE Publications Reprints and permissions: sagepub.com/journalsPermissions.nav DOI: 10.1177/1075547014529093 scx.sagepub.com

\$SAGE

Leona Yi-Fan Su¹, Michael A. Cacciatore², Dietram A. Scheufele¹, Dominique Brossard¹, and Michael A. Xenos¹

Abstract

This study assesses two key types of knowledge assessments, factual and perceived knowledge, in the study of knowledge gaps. In addition, we distinguish between communication channels in exploring the phenomenon, examining nanotechnology knowledge gaps based on levels of attention to traditional media, science blog use, and the frequency of interpersonal discussion. Using regression analysis, we find that how researchers measure knowledge can significantly affect the discovery of gaps. We also find differential effects based on communication channels, including evidence that the direction of perceived gaps in knowledge can be reversed as media consumption increases. Implications of these findings are discussed.

Su, Leona Yi-Fan, et al. "Inequalities in Scientific Understanding Differentiating Between Factual and Perceived Knowledge Gaps." *Science Communication* 36.3 (2014): 352-378. doi: 10.1177/1075547014529093

Scientific Challenges

- Identification and characterisation of nanoparticles within the food matrix
- Uptake and absorption
- Safety



Measurement of Nanomaterials in Foods: Integrative Consideration of Challenges and Future Prospects

Christopher Szakal,[†] Stephen M. Roberts,[‡] Paul Westerhoff,[§] Andrew Bartholomaeus,^{⊥,||} Neil Buck,[¶] Ian Illuminato,[#] Richard Canady,[^] and Michael Rogers[▽],^{*}

Abstract

The risks and benefits of nanomaterials in foods and food contact materials receive conflicting international attention across expert stakeholder groups as well as in news media coverage and published research. Current nanomaterial characterization is complicated by the lack of accepted approaches to measure exposure-relevant occurrences of suspected nanomaterials in food and by broad definitions related to food processing and additive materials. Therefore, to improve understanding of risk and benefit, analytical methods are needed to identify what materials, new or traditional, are "nanorelevant" with respect to biological interaction and/or uptake during alimentary tract transit. Challenges to method development in this arena include heterogeneity in nanomaterial composition and morphology, food matrix complexity, alimentary tract diversity, and analytical method limitations. Clear problem formulation is required to overcome these and other challenges and to improve understanding of biological fate in facilitating the assessment of nanomaterial safety or benefit, including sampling strategies relevant to food production/consumption and alimentary tract transit. In this Perspective, we discuss critical knowledge gaps that must be addressed so that measurement methods can better inform risk management and public policy.

Issues – moving forward

- Many potential benefits but must also identify any potential risks
- Various governments/agencies are in the process of developing policies/regulations
- Need to educate consumers/public to avoid a repeat of the discussion involving Genetically Modified Organisms

Global Initiatives

NanoLyse

http://www.nanolyse.eu/default.aspx

"The NanoLyse project is a European collaborative research project which is partly funded by the European Commission under the 7th Framework Programme. It is dedicated to the development of analytical methods for detection and characterisation of engineered nanoparticles in food. The NanoLyse consortium comprises 10 universities and research centres from Europe and Canada and is coordinated by RIKILT - Institute of Food Safety (Wageningen UR).

NanoRelease

http://www.ilsi.org/ResearchFoundation/RSIA/Pages/FoodAdditiveMainPage.aspx

- "The NanoRelease Food Additive project will identify, evaluate, and develop methods needed to confidently detect, characterize, and evaluate intentionally produced nanoparticles released from food along the alimentary tract, as occurring through direct food additives or indirect incorporation in food through migration from food contact materials or environmental contamination."
- ILSI Research Foundation

IUFoST - International Society of Food Applications of Nanoscale Sciences (ISFANS)

- Goal: is intended to provide the means and the infrastructure for efficient interactions among participants globally. ISFANS will not only help to speed up and improve the research and developments, it will also serve to identify critical gaps and avoid unnecessary duplication of efforts. It will be a means to bridge the divide between research, application and policy/regulations and will speed up the valorization of the results of food applications of nanoscale science, engineering and technology to benefit the society.
- Mission: ISFANS was created (August 2010) to strengthen research, communication, dissemination of information and networking for technology transfers and international collaborations among interested parties from academia, industry, government, consumers, and other stakeholders around the world.

http://www.iufost.org/International-Society-Food-Applications-Nanoscale-Sciences

Acknowledgments

- Dr. Jose Aguilera, Catholic University of Chile
- Dr. Qasim Chaudhry, Food and Environment Research Agency (FERA), UK
- Dr. Hongda Chen, National Institute of Food and Agriculture, USDA
- Dr. Lekh Juneja, Taiyo Kagaku, Japan
- Dr. Berna Magnuson, Univ. Toronto
- Dr. J.D. McClements, Univ. Massachusetts
- Dr. Michael Nickerson, Univ. Saskatchewan
- Dr. Al Paulson, Dalhousie University
- Dr. Derick Rousseau, Ryerson University
- Ms. Lori Sheremeta, National Institute of Nanotechnology, Edmonton
- Dr. Jochen Weiss, Univ. Hohenheim
- Natural Sciences and Engineering Research Council of Canada
- Canada Research Chairs Program
- Advanced Foods and Materials Canada
- IUFoST, ISFANS









Some nanofood for thought Muchas Gracias

Rickey Y. Yada

Professor and Canada Research Chair
Scientific Director, AFM Canada
President Elect, IUFoST
Brian Bryska
Department of Food Science
University of Guelph
Guelph, ON, Canada N1G 2W1
ryada@uoguelph.ca

