Nanotechnology in Food: Lessons from the Industrialization and Enrichment of Bread

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Abstract

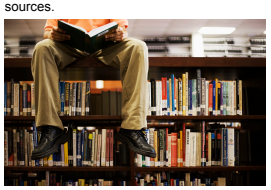
How should we understand new applications of nanotechnology to our food? Helmut Kaiser Consultancy expects research funding for the application of nanotechnology in food to reach $30 billion by 2015. Currently, an Australian bread company, Tip Top Bakeries, aims to combat heart disease by using nano-encapsulation technology to enrich its white bread with Omega-3 fatty acids. However, nano-encapsulation does not affect the high glycemic index in Tip Top's white bread, and studies show the consumption of a high glycemic load increases risk of heart disease.

Building on these concerns, my poster offers an applied history of prior technological interventions in bread production in order to contextualize and obtain possible lessons for the new development of nanotechnology in food. The history of technological innovation in the bread industry revealed an unmistakable pattern: narrow-sighted technological solutions to challenges in bread production repeatedly produced new problems and unintended consequences for human health.

The history of bread technology—in addition to general uncertainties surrounding the toxicity of ingested nanomaterials, the unknown behavior of most nanoparticles in biological contexts, and the nearly absent regulation of nanomaterials in food—suggests the need for caution in the development of nanofood technology. Furthermore, future applications of nanotechnology in food need to provide tangible benefits to overcome the daunting risks of uncertainty associated with nanotechnology in food.

Research Methods

History is based on rigorous empirical standards. No historical theory can be taken seriously unless it is based on a solid foundation of evidentiary support. In order to provide support for historical theories, historians cite primary and secondary sources.



Primary Source: A primary source is a document or physical object written or created during the time under study. An example of a primary source used in this project is Friedrich Accum's classic work, *A Treatise on Adulterations of Food and Culinary Poisons*. It provides a first hand account of food adulteration practices from the early 19th century.

Secondary Source: A secondary source offers an account of an historical event produced after the time period in question. An example of a secondary source is Aaron Bobrow-Strain's, *White Bread: A Social History of the Store-Bought Loaf*, which provides a history of white bread in America. It draws on primary sources from the 20th century.

Techological Fixes for White Bread

White Bread (pre-19th Century)

Before the 19th century, white bread was made with white flour hand-milled by stone and aged in the open air.

Problem: White Flour Expensive

Pre-19th century white flour was a symbol of wealth. It was not available to a mass market because it was time intensive and expensive to produce.

Tech Fix: Aluminum Sulfate (19th Century)

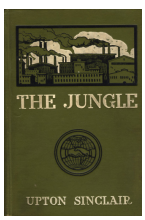
Throughout the 19th century, bread-bakers used Aluminum Sulfate, also known as Alum, to whiten wheat flour cheaply. The practice became widespread in both Europe and the United States.

"[W]ithout the addition of alum, it does not appear possible to make white, light, and porous bread, such as is used in this metropolis, unless the flour be of the very best quality."
- Friedrich Accum *A Treatise of Adulterations of Food and Culinary Poisons* (1820).

New Problems: Health and Social Issues (early 20th Century)

Health Problems: Ingestion of Alum contributed to aluminum poisoning, digestive trouble, rickets, and neurodegenerative diseases.

"Alum exerts, especially in continued use, very injurious effects on the body, and exactly this method of adulteration is one of the most dangerous."
- Henry A. Mott "The Effect of Alum Upon the Human System" (1880)



Social Problems: The use of Alum in bread contributed to an outcry against adulterated food. An atmosphere of suspicion and fear surrounding food in the early 20th century resulted in the 1906 Food and Drug Act, which created the U.S. Food and Drug Administration (FDA).

Tech Fix: Steel Roller Milling/Chemical Bleaching (20th Century)

Industry responded to social demands for "pure" white bread with new technologies. Steel Roller Milling and Chemical Bleaching produced a white flour "untouched by human hands."

Steel Roller Milling removed bran and germ from wheat grain. The resulting flour contained only endosperm, which is high in carbohydrates and low in vitamins and minerals.

Chemical Bleaching further whitened the residual color remaining from steel milling. The bleaching agents included Chloride Dioxide, Nitrogen Dioxide, and Organic Peroxides.

New Problems: Nutrient Degradation/Malnutrition/Unfit Troops

Before World War II, nutrient deficiency disorders increased.

Removing bran and germ from white bread with steel milling and bleach eliminated the majority of wheat flour's key vitamins and minerals, including Vitamin A, B Vitamins, Vitamin E, Iron, Calcium, and Omegas 3s. Lack of Vitamin A and various B Vitamins contributed to some of the most serious disorders.

Nutrient deficiencies resulted in large numbers of Americans unfit for battle. The lack of vitamins in bread became a matter of national security.

Tech Fix: Enrichment of White Bread (1943)

In 1943, President Franklin D. Roosevelt signed the War Food Administration Order No. 1, which mandated the enrichment of commercially produced white flour.

This war-time order standardized the enrichment of white flour in America.

"An order directing bakers to increase further the vitamin content of white bread has been prepared by the War Food Administration…"
- "Bread to be Richer in Vitamin Content," *New York Times* (June 18, 1943).

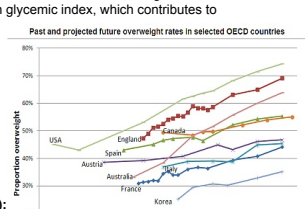
New Problems: Obesity Epidemic (Today)

Enrichment of white bread successfully combated nutrient deficiencies, but it ignored underlying health problems. White bread has a high glycemic index, which contributes to obesity, diabetes, and heart disease.

"[H]igh dietary glycemic load from refined carbohydrates increases the risk of CHD, independent of known coronary disease risk factors."
- Simin Liu, et. al, "A Prospective Study of Dietary Glycemic Load, Carbohydrate Intake, and Risk of Coronary Heart Disease in US Women," (June 2000).

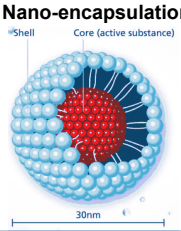
The industrialized world currently faces an obesity epidemic. The two leading obesity related killers are diabetes and heart disease.

Glycemic Index:
White Bread (avg.): 75
Table Sugar (avg.): 65



Organization for Economic Cooperation and Development: http://economix.blogs.nytimes.com/2010/09/23/the-world-is-fat/

Nano-encapsulation



Nano-encapsulation technology has two main parts: a *core substance* and a *nano-sized capsule or shell*. Nano-capsules deliver core substances in a selective manner. A variety of shell materials can deliver a variety of core substances. The properties of the shell substance determine the properties of the nano-capsule.

Tech Fix: Nano-encapsulation in Bread

An Australian Company called Tip Top Bakeries produces a product that uses nano-encapsulation technology to enrich bread with Omega 3s. The nano-enrichment intends to combat heart disease.

No nanotoxicology tests have been performed to evaluate the safety of nanoencapsulation materials.

Other Current Nanofood Applications

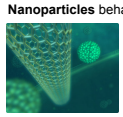
Titanium Dioxide is used as a food whitening additive. A recent study found titanium dioxide nanoparticles in common food products containing food grade titanium dioxide

Alex Weir et. al., "Titanium Dioxide Nanoparticles in Food and Personal Care Products," *Environ. Sci. Technol.* 46 (2012): 2242-2250.

The food industry plans many new uses of nanoparticles in food. Nanoparticles have unique properties, but we do not know how they will effect the human body.

Uncertainties of Nanotechnology

Nanoparticles behave differently than their bulk counterparts in biological systems, but precise interactions remain unknown.



Nanotoxicology methods are currently insufficient to evaluate their safety.

Andrew Maynard, et al, "The New Toxicology of Sophisticated Materials: Nanotoxicology and Beyond," *Toxicol. Sci.* 120 (2011): S109-S129.

Regulatory bodies lack data for proper health & safety determination on nanofood.

FDA et al, *Draft Guidance for Industry… on the Safety and Regulatory Status of Food Ingredients* (April 2012)

Conclusions

1) The history of bread suggests that nanotechnology in food, like many earlier technologies, may create unintended consequences.

2) Uncertainties surrounding nanotechnology indicate that more research is needed to its ensure safety in human foods.

3) Current applications of nanotechnology in food do not yet justify the risk of uncertainty associated it. Better and more beneficial applications are needed in order for the risk/benefit analysis of nanofoods to balance out.

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Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. SES0938099. Any opinions, findings, and conclusions or recommendations expressed in this **material are those** of the author(s) and do not necessarily reflect the views of the National Science Foundation.