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Addressing Nanotechnologies in Organic Standards and Regulations: Should nanotechnology and nanoparticles be allowed or prohibited in organic production, and under what conditions? IFOAM takes up the issue.

Food, Agriculture and Nanotechnology: Applying the Snow White Test to the Nano-Apple

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Abstract

Eight consumer surveys over five years, with over eight thousand subjects and across two continents yield three clear results. They are that, firstly, consumers are generally ignorant about nanotechnology, secondly, they are generally optimistic about nanotechnology and, thirdly, despite the general optimism, they draw the line at food, they do not want nanotechnology in their food. Nano-food fails the Snow White Test: Is this a transaction that would proceed if, between the parties, there was symmetry of information about the product? If nanomaterials are used in food production consumers want to be informed so they can exercise choice. There are three available responses that honour these sentiments towards nano and food, and they are, firstly, to ban nanotechnology from the food stream, or secondly, to label nanofood, or thirdly, to label non-nanofood. Two recommendations are presented. The organic sector has both the capacity and the imperative to exclude nano from its food stream, and hence to adopt the third option. The implementation of a nano-exclusion involves adopting a no-nano clause in organic standards. The organic standards of Australia, the UK Soil Association, and of Demeter-International have already implemented such an exclusion. For such exclusions to be effective there needs to be a watching brief on nanotechnology developments and implementations that may impact food and agriculture so that the integrity of the exclusion is maintained, not only in intention but also in practice.

Keywords: consumer attitudes, community attitudes, nanomaterials, nanoparticles, nanofood, organic food, organic farming, IFOAM.

Engines of Creation

Eric Drexler (1986) in his book *Engines of Creation - The Coming Era of Nanotechnology* wrote with insight, enthusiasm and prescience. His vision for nanotechnology remains almost totally unfulfilled which is perhaps a reminder that, despite this already being a multi-billion dollar industry with a reach into most sectors of the economy, the nanotechnology journey has barely begun.

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Drexler posed the question "What is possible, what is achievable, and what is desirable?" (1986, p.39). He was aware that this is a technology with a vast potential and requiring vigilance and oversight. Drexler asked "are we too wicked to do the right thing ... too stupid to do the right thing ... too lazy to prepare" (p.200).

Much of the nano-research funded to date is military research. However, agriculture is already being targeted for nano-applications, and military research and developments are not matters of indifference to agriculture since military chemical research and developments have in the past been promptly repurposed for agriculture. The production lines for nitrogenous explosives in WWI were quickly repurposed to produce synthetic nitrogenous fertilizer for farmers, and the results of chemical warfare experiments of WWII were promptly migrated to wide-scale application in agriculture, DDT and sodium fluoroacetate (Compound 1080) being two such examples.

Definitions, Revolutions & Products

A definition of nanotechnology is:

> "Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications … Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale. These properties may differ in important ways from the properties of bulk materials and single atoms or molecules" (NSTC, 2011, p.3).

The US Environmental Protection Agency (EPA) defines a nanoscale material, a nanomaterial, as:

> "an ingredient that contains particles that have been intentionally produced to have at least one dimension that measures between approximately 1 and 100 nanometers" (Jordan, 2010, p.6).

The US government budget for nanotechnology research in 2011 is US$2.27 billion (NSTC, 2010). This comprises US$1.76b within the National Nanotechnology Initiative (NNI) plus US $0.51 billion through the American Recovery and Investment Act (ARRA) (NSTC, 2010). The NNI, founded in 2001, has expended US$14 billion on nanotechnology research over the decade. The US Department of Defense (DOD) has been the biggest single beneficiary of this research funding, spending US$459.0 million in 2009, which was 27.0% of the NNI nano-research budget. The United Stated Department of Agriculture (USDA) spent US$15.3 million on nano-research in 2009, which was 0.9% of the NNI nano-research budget (NSTC, 2010).

The US Food and Drugs Administration (FDA) states that:

> "Nanomaterials often have chemical, physical, or biological properties that are different from those of their larger-scale counterparts. Such differences may include altered magnetic, electrical, or optical properties, structural integrity, and chemical or biological

> activity. Because of researchers' ability to engineer such properties, nanoscale materials have great potential for use in a vast array of products" (NSTC, 2010, p.21).

The nano-research of the US National Institute of Food and Agriculture (NIFA) of the USDA is stated to include the "effective and safe delivery of bioactives in functional foods for improving human health and wellness" (NSTC, 2010, p.25). Looking ahead, the NIFA identifies "Future opportunities for … using plants or animals … to produce specifically constructed nanomaterials at low cost in genetically engineered organisms" (NSTC, 2010, p.26).

The NNI has four goals, to promote firstly, research, thirdly education, and fourthly development (NSTC, 2010). Goal 2 of the NNI is to "Foster the transfer of new technologies into products for commercial and public benefit" (NSTC, 2010, p.32). The NNI presents as an example of meeting Goal 2: "Munitions enhanced with nano-aluminium powder. … to give lethality enhancements in miniaturized munitions". Such weapons "may give improved lethality by improving the airblast and the shrapnel accelerating capability" (NSTC, 2010, p.33). The "DOD considers nanotechnology to have high and growing potential to contribute to the warfighting capabilities of the nation" (NSTC, 2010, p.17).

According to the NNI "The United States has set the pace for nanotechnology innovation world-wide with the National Nanotechnology Initiative" (NSTC, 2011, p.1) The NNI's vision is "of a future in which nanotechnology benefits society through a revolution in technology and industry" (NSTC, 2011, p.iii). The NNI declares that "Global issues are interwoven among each of the NNI's four goals" (NSTC, 2011, p.34). A focus of the NNI is rapid broad-scale commercialization of nanotechnology:

> "Maximizing the benefits of nanotechnology developments to the U.S. economy also requires efforts to remove barriers to global commercialization and an understanding of the potential markets for a given product" (NSTC, 2011, p.25).

The US Department of Agriculture (USDA) asserts:

> "Nanoscale science, engineering, and technology have demonstrated their relevance and great potential to enable revolutionary improvements in agriculture and food systems, including plant production and products; animal health, production, and products; food safety and quality; nutrition, health, and wellness; renewable bioenergy and biobased products; natural resources and the environment; agriculture systems and technology; and agricultural economics and rural communities" (NSTC, 2011, p.16).

The NNI's vision is not of some incremental increase of the global store of knowledge, it is about revolution, with a US-centric flavour. This raises three important questions: do 'we' want food and agriculture revolutionized, and if so do 'we' want the US government guiding that process, and thirdly, do 'we' want US patents reaping the dividend?

The US EPA reports that at least one pesticide on the US market already contains nanomaterial (nano silver), and that "There are likely other registered pesticides that contain nanoscale material" (Jordan, 2010, p.12).

A recent inventory of consumer products containing nanotechnology identified and classified 1014 nano-products by region of origin, and into eight categories (Figs.1&2) (PEN, 2010). Nine percent of identified products were in the 'Food and Beverage' category (Fig.3). Of this category the largest sector was food supplements (Fig.4).

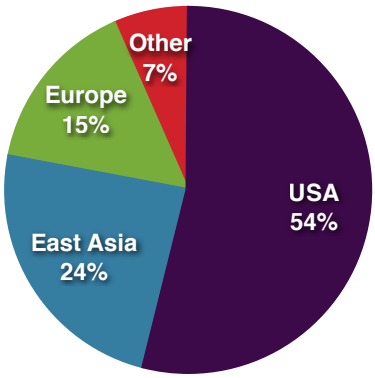

Figure 1. Region of origin of nanotechnology consumer products currently in the market (N=1014) (PEN, 2010).

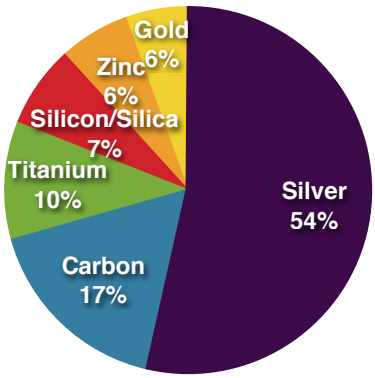

Figure 2. Nanomaterials specified in nanotechnology consumer products currently in the market (N=483) (PEN, 2010).

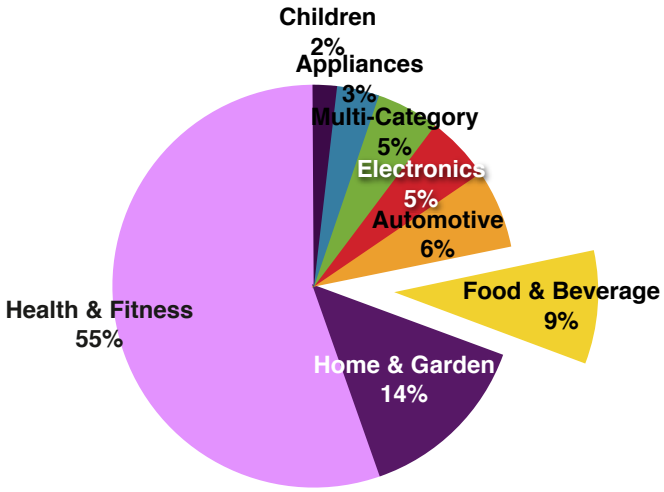

Figure 3. Distribution by category of nanotechnology consumer products currently in the market (N= 1014) (PEN, 2010).

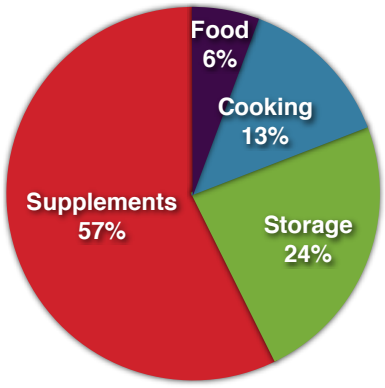

Figure 4. Distribution by sub-category of nanotechnology products classified as 'Food and Beverage' (N= 97) (PEN, 2010).

Consumer Attitude Surveys

Data from eight surveys of consumer attitudes to nanotechnology are presented from national surveys in Australia and the USA, of randomly selected subjects, from 2005 to 2009. Four of these surveys were conducted in Australia: 2005 (N=1000); 2007 (N=1000); 2008 (N=1100); 2009 (N=1100), (MARS, 2010), and four were conducted in USA: 2006 (N=1014); 2007 (N=1014); 2008 (N=1003); 2009 (N=1001), (HRA, 2006, 2007, 2008a, 2009).

Consumer Attitude Survey Results

A female survey respondent from Queensland stated that:

> "I don't know how it works. Overall I feel positive about nanotechnology because it seems like it can help in a lot of areas. But I don't want nanotechnology included in food" (MARS, 2010, p.5).

That single comment sums up the outcome of eight surveys, over five years, involving more than 8000 subjects, and two continents. Respondents in both Australia and USA reported that they knew little or nothing of nanotechnology (Fig.5). Respondents stated that they felt positive about science and technology, and this sentiment remained stable across five years (ranging from 81% to 89%) (Fig.6). Respondents were aware of a risk/benefit trade-off, with Australians most inclined (46%) to report that nanotechnology benefits exceed risks, and Americans most inclined to respond "Don't know" (48%) (Fig.7).

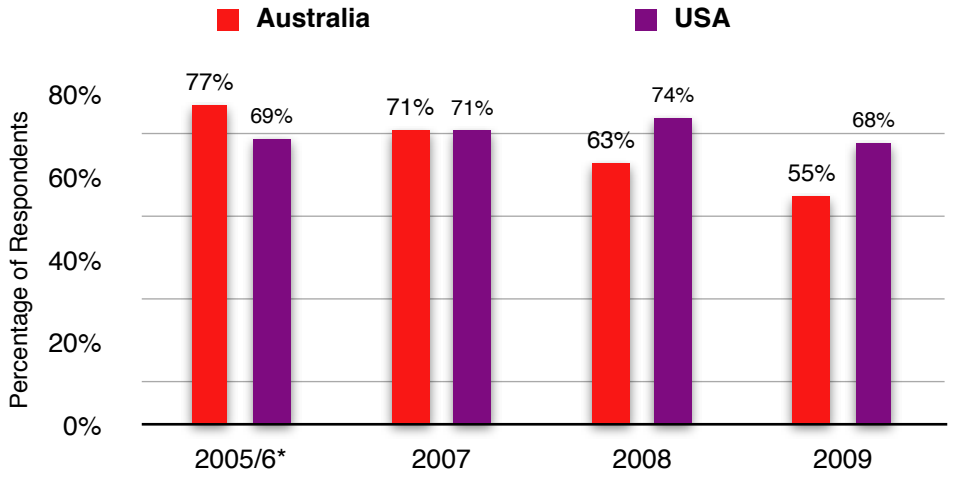

Figure 5. Percentage of US respondents who know little or nothing about nanotechnology (N=1014; N=1014; N=1003; N=1001; HRA, 2009) (PEN, 2010). Percentage of Australian respondents who have not heard the term nanotechnology or don't know what it means (N=1000; N=1000; N=1100; N=1100; MARS, 2010). * 2005 for Australian sample; 2006 for US sample.

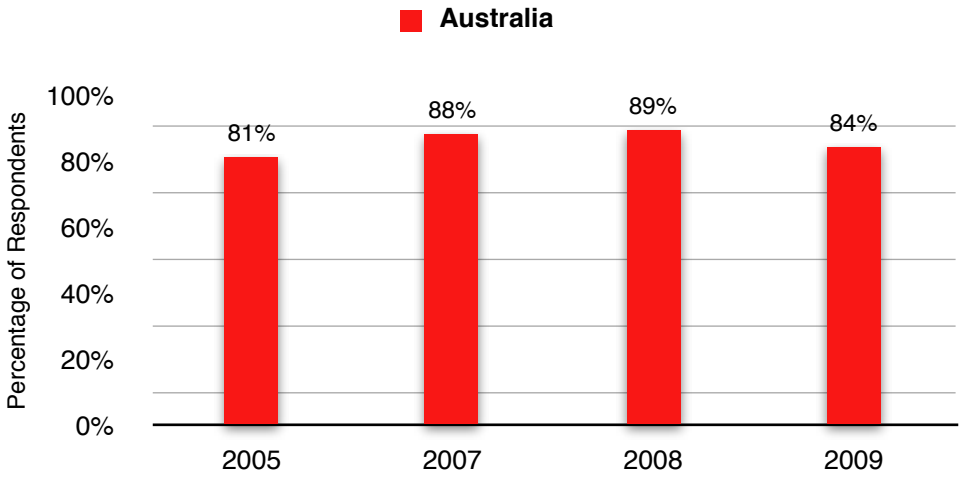

Figure 6. Percentage of respondents who "feel positive about science developments" (MARS, 2010).

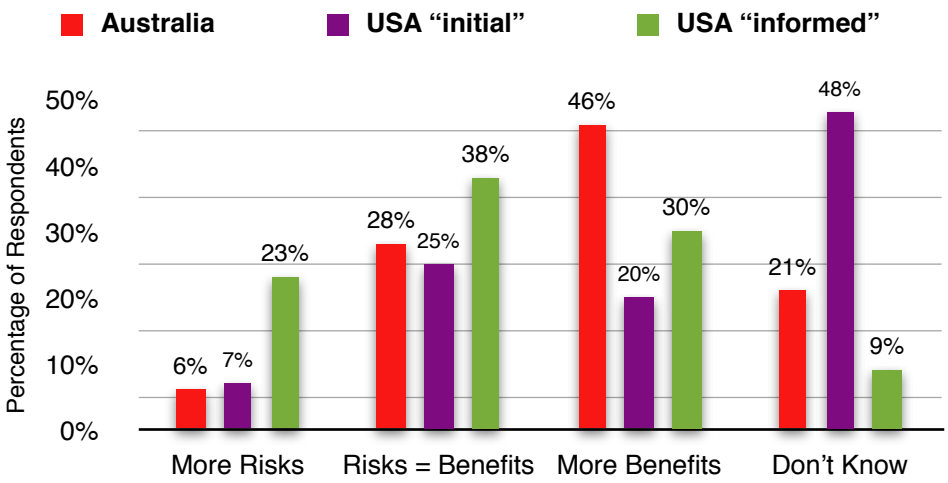

Figure 7. US and Australian respondent's impressions of the risks versus the benefits of nanotechnology; USA (HRA, 2008b) (2009 na) & Australia (MARS, 2010).

Food & Labelling

Respondent expressed concerns about safety and, in particular, were wary of nanotechnology in food. Of US respondents, only 7% indicated that they would purchase food 'enhanced with nanotechnology' (HRA, 2007) (Fig.8). Eighty percent of Australian respondents were concerned about public or worker safety (Fig.9). Long term side effects were a matter of concern to 63% (Fig.10). Sixty percent of respondents were concerned about the lack of nano-regulation (Fig.11), and 81% of respondents were concerned that nanofood should be labelled (Fig.12).

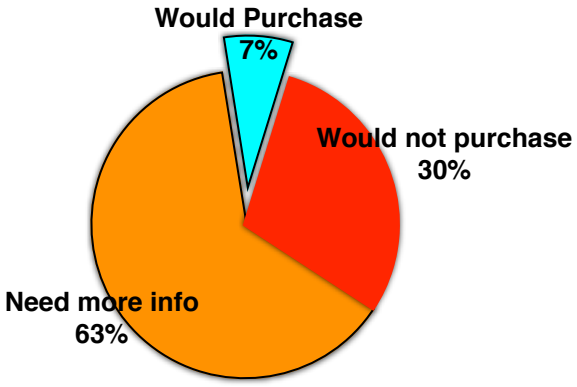

Figure 8. Percentage of US respondents: "I would purchase food enhanced with nanotechnology"; "I would NOT purchase food enhanced with nanotechnology" or "I need more information about health risks and benefits to purchase food enhanced with nanotechnology" (N = 1014) (Data source: HRA, 2007) (no data for 2008 & 2009).

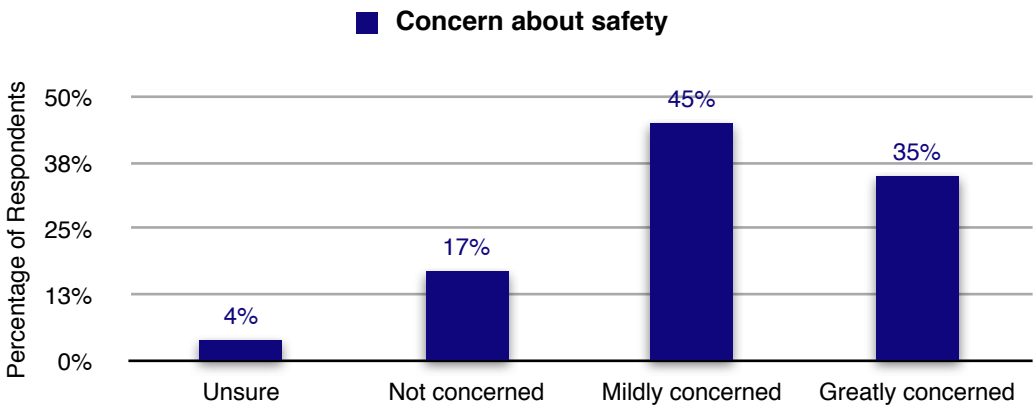

Figure 9: "Because nanotechnology is so new there might be problems for public safety or worker safety" Australian subjects (N = 1100) (MARS, 2010).

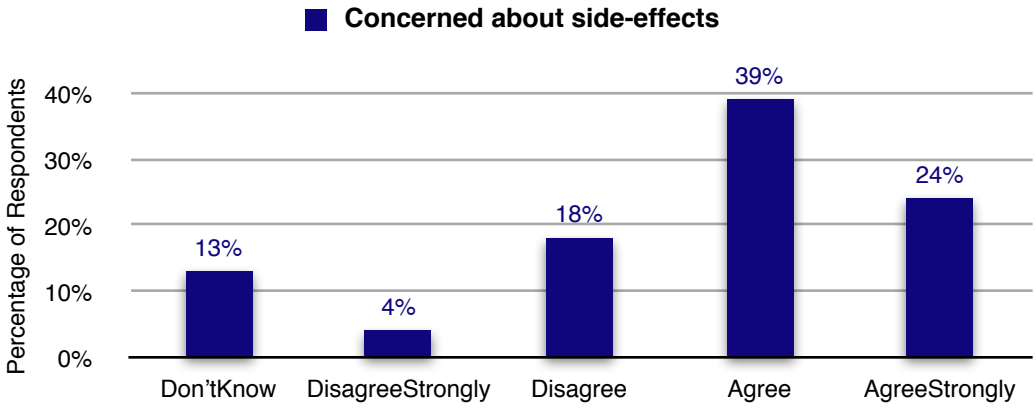

Figure 10: "I am concerned about the long-term side effects of nanotechnology" (N = 1000) (MARS, 2007).

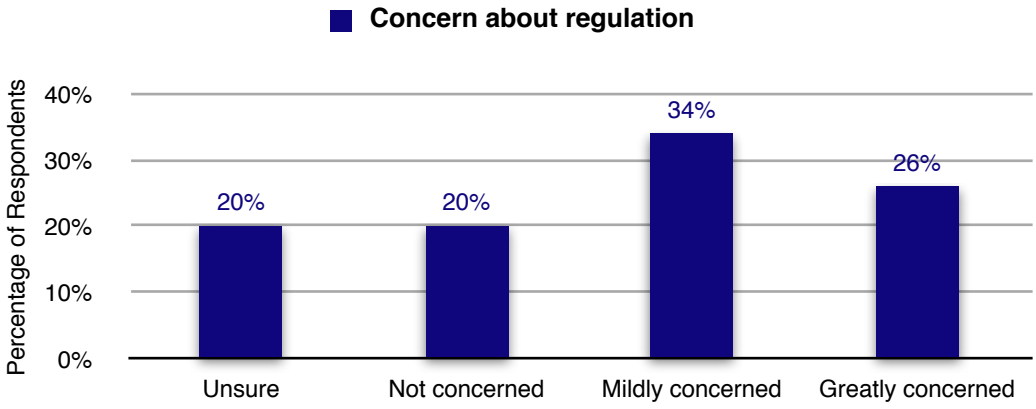

Figure 11: "Nanotechnology regulation and standards are not keeping up with the development of nanotechnology" (N = 1100) (MARS, 2010).

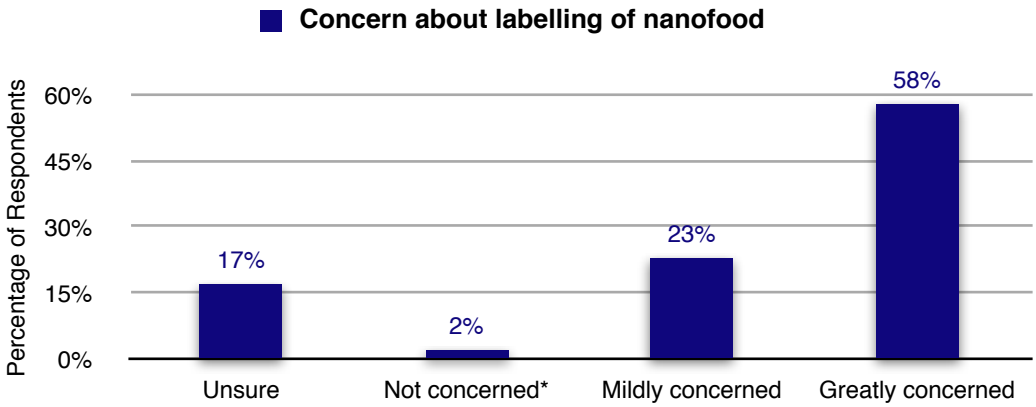

Figure 12: "Food labelling should provide information about any nanotechnology used" (N = 1100) (MARS, 2010) (*datum redaction, misprinted in 2010 report; personal communication from the report authors, 2011).

Snow White and Knowledge Symmetry

The issue of the application of nanotechnology to food is new, however the issue of food integrity is an issue of long standing. It is an issue largely about the asymmetry of knowledge, and how to remediate such asymmetry.

Nanotechnology is but a fresh exemplar of the broader issue of cryptic technologies introduced into food, that is technologies hidden from the view of the consumer. Two centuries ago Jacob and Wilhelm Grimm introduced the world to Snow White, and she faced this very issue. Initially she presents as a fairly naive consumer, and although she receives admonitions for vigilance from her house-mates, she ultimately she has a negative food experience with a poisoned apple.

The point is, if Snow White knew more would she eat less? And if she knew the apple was poisoned would she have eaten it? She did challenge the supplier and was given verbal reassurance together with a practical demonstration of the safety of the apple. The story demonstrates the shortcomings of self-regulation and first party certification. Snow White's problem has two aspects: firstly, the toxicity of the apple is not apparent and is not knowable by any inspection process available to her; and secondly, there is an asymmetry of information with the supplier aware of the provenance and history of the apple but this information is not available to the recipient.

The Snow White Test applied to a transaction is this: Is this a transaction that would proceed if, between the parties, there was symmetry of information about the product? If Snow White knew what the wicked Queen knew about the delicious-looking poisoned apple would she still eat it? The answer is clearly no. In the case of a nano-apple, while the Grimms are understandably silent, survey respondents indicate a reluctance to choose nano-food (Fig.8).

A nano-apple? Such an apple might have been produced by 'known' fertilizers or pesticides reformulated with nano-ingredients, or new fertilizers or pesticides formulated with nanomaterials. A nano-apple may have received a post-harvest nano-treatment. It may have been packed or sorted on surfaces treated with nanotechnology. It may have been stored or transported in a nano-enhanced environment or in packaging incorporating nanotechnology. Is the nano-

apple safe, or how safe, and do 'we' want to eat it, are unknowns. In terms of the ultimate 'safety' of such nano-ingredients, and their biological and environmental fates, these are matters for which research can provide answers, if at all, only in the long term and over decades, and for the present they remain unknowable.

Snow White's unfortunate apple experience exemplifies the enduring danger of supplier's own assurances and demonstrations of safety. In the Grimms' story, the supplier's self-certification of the safety of an apple that *looked* delicious proved misleading and valueless.

So how can Snow White be saved? There are three scenarios under which she can at least be empowered to make an informed choice:

> **Scenario 1**: the cryptic ingredient, be it the Queen's poison or nanomaterials, is banned.
>
> **Scenario 2**: the apples that *include* the cryptic ingredient are labelled.
>
> **Scenario 3**: the apples that *exclude* the cryptic ingredient are labelled.

The implementation of any of these scenarios corrects the information deficit for Snow White, as our proxy-consumer, and provides the opportunity of avoiding a particular cryptic ingredient or class of cryptic ingredients, for example, nanomaterials.

Scenario 1 has been proposed for nanomaterials and food. In 2007 the International Union of Food, Farm and Hotel Workers (IUF, 2007) called for such a moratorium on nanotechnology. In 2010 the Members of the European Parliament called for a moratorium on nano in food (Nanoforum, 2010).

Scenario 2 has been proposed by Members of the European Parliament requiring, under their proposal, that any approved nano-ingredients be mentioned on food-labels (Nanoforum, 2010).

Scenario 3 is an option ideally suited for adoption by the organics sector. It is the only one of the three nanotechnology-in-food scenarios that can readily piggyback on an existing food stream, that already has third-party oversight, has global reach, has local and international standards, and has known labelling schemes in place.

Standards, Organics and Nano

At least three organics standards already exclude nanotechnology. The Australian National Standard for Organic and Bio-Dynamic Produce of 1 July 2007 stated that:

> "Products or by-products … that are manufactured/produced using nanotechnology, are not compatible with the principles of organic and bio-dynamic agriculture and therefore are not permitted under the Standard" (OIECC, 2007, p.5).

The point was reiterated: "The final product, or any of its ingredients, must not have been subject to treatments involving the use of … nanotechnology" (OIECC, 2007, p.44). Australian organic

standards have evolved through several iterations since the 2007 standard, and the nano-exclusion has been retained.

The UK Soil Association Standard of 2008 stated that "Nanoparticles are commonly defined as measuring less than 100 nm" (SA, 2008, p.92) and it operationalized the exclusion by providing the double test of prohibiting "ingredients containing nanoparticles" where: (a) "the mean particle size is 200 nm or smaller" and (b) "the minimum particle size is 125 nm or smaller" (p. 93). The Standard made the important distinction that the intent here was to exclude "engineered nanoparticles" while recognizing that "some established manufacturing processes" may "incidentally" produce nanoparticles, an issue that would require further investigation (p.93).

The Demeter standards apply internationally to biodynamic food and agriculture and Demeter-International is the only international labelling and standards scheme with a global reach that currently excludes nanomaterials. The Demeter standard states:

> "Demeter-International adopts the precautionary principle in the implementation of nanotechnology, and therefore excludes it from all usage in Biodynamic agriculture, and from all Demeter certified products. DI will monitor developments in the field of nanotechnology, including the stance of other organic certifiers and review this policy in the light of new information that becomes available" (Demeter-International, 2010, p.29).

Of the three scenarios, it is only Scenario 3 that is within the capacity of the organics sector to implement. Organics is already a differentiated food stream and the exclusion of nanotechnology from its food stream is congruent with the maintenance of a safe and healthy food stream. Inaction risks breaching the social contract with organic consumers who expect the delivery of healthful natural food without synthetic inputs.

Conclusions

Consumers are, in general, ignorant of nanotechnology, are unconvinced that sufficiently strong regulation and safety standards are in place, are wary of nanofood, express an unwillingness to purchase it, would want more information before eating it, and want labelling so that they have a choice. In short, there is no consumer demand, no consumer pull, for nanofood. The push for nanofood is from government and corporate interests with their own commercialization agendas. The USA's NNI, for example, has the vision and ambition to revolutionize food and agriculture on a global scale and protected by US patents (NSTC, 2011).

The organics sector is ideally, and even uniquely, positioned to put a nano-exclusion in place. Its customer base places its trust in organic certification to exclude synthetic chemicals - and nano materials clearly fall into this category. This means that there is an imperative to honour the social contract with organics consumers by implementing a nano-exclusion. Such an exclusion potentially broadens the customer-base for organics to those who seek a nano-free diet but have not, otherwise, subscribed to the organics philosophy. And, importantly, the organics sector offers assurances that are third-party assurances.

Nanotechnology has been described as "the next challenge for organics" as well as the next opportunity (Paull & Lyons, 2008). The organics sector already has a food stream and an associated label which excludes synthetic fertilizers, pesticides, food irradiation and GMOs. It has a clientele that values food without synthetic ingredients. A sector-wide nano-exclusion meets the expectations of the existing organics constituency as well as meeting the aspirations of consumers as measured in surveys reported here in both Australia and USA. A nano-exclusion offers the new marketing potential to promote organic products to consumers as 'nano-free' or 'produced without the use of nanotechnology'.

Recommendations

The IFOAM AGM in Korea in September 2011 presents an opportunity to extend the nano-exclusion beyond Australian, Soil Association, and Demeter-International standards, and to implement a global nano-exclusion for the whole organics sector. These three organics standards that already have nano-exclusions in place provide models for a sector-wide exclusion.

Recommendation 1: The adoption of a sector-wide exclusion of synthetic nanomaterials. This acknowledges the uncertainty of safety of such materials and the incongruence between the organics philosophy and nano-in-food.

Recommendation 2: The implementation of watching brief on nanotechnology. This recognizes that this is a technology that is evolving and developing rapidly, is still in its infancy, and is driven by a massive research effort with the stated objectives of rapid commercialization and of revolutionizing industries. Paull & Lyons (2008) identify three modes of nano-contamination of foodstuffs: intentional (for example by nano-additives); incidental (e.g. by migration from nano-packaging); and adventitious (e.g. from nano spray drift). The organics sector needs to develop an ongoing awareness of developments in nano-packaging, surface treatments, fabric treatments, input reformulations, post harvest treatments, seed treatments, filtration technologies, *et alia*, so that the integrity of a nano-exclusion is maintained. Protecting the organics stream from these three modes of nano-contamination will require ongoing vigilance.

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