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Nanomaterials in food and agriculture: The big issue of small matter for organic food and farming

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Abstract

Nanotechnology is the study of very small matter, of materials where one dimension is less than 100 nanometres. Surveys reveal that consumers are generally ignorant of nanotechnology, are concerned of its risks versus benefits, expect labelling of products incorporating nanotechnology, and a big issue for respondents is particularly the use of nanotechnology in food. Organic standards of Australia, Canada, Demeter-International and the UK's Soil Association exclude nanomaterials, however a general nanotechnology exclusion across the organics sector is lacking.

Introduction

Nanotechnology is the study of small matter. The US EPA's new "working definition" of "nanoscale material" is: "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). A nanometre is a billionth of a metre. Small matter can behave differently from big, and, at the nanoscale materials can exhibit novel and unpredicted properties, and that is a major aspect of the motivation behind the US government budgeting US$1.8 billion for nano-research in 2011. The National Nanotechnology Initiative (NNI, 2010, p.1) states that: "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".

A set of new properties and behaviours can be exciting from a scientific perspective, however regulations on the use of materials have not caught up with this scientific development, and the potential risks and toxicities of nanomaterials will likely take decades to evaluate. This suggests the wisdom of taking a precautionary approach.

The nanotechnology industry is moving quickly from promise to reality. The cover of Ed Regis' 1995 book *Nano!* hailed nanotechnology as "the astonishing new science that will transform the world". Global nanotechnology sales for 2009 were valued at US$11.7 billion (McWilliams, 2010). This rapid advance has engaged diverse industry sectors, including food and agriculture, in what is essentially a regulatory vacuum.

The Woodrow Wilson Center has identified 1015 nano consumer products on the market (PEN, 2010). Of these the biggest category is "Health and fitness" (N=605). There are 98 products in the "Food and beverage" category. Nano-silver is the most commonly identified nonmaterial, used for its antimicrobial properties (N=259). The USA is the lead producer of items in their inventory (N=540). This inventory relies on self-declared marketing claims, and so it presents an underestimate of the total nano-

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offerings in the consumer marketplace. According to Jordan (2010) there is already at least one agricultural pesticide on the US market that includes nanomaterials.

The implementation of nanotechnology has proceeded in advance of both government regulation and social sanction. This paper examines attitudes of the public to nanotechnology. Is the use of nanotechnology in food and agriculture a big issue and if so what are appropriate and available responses?

Materials and methods

Data from surveys of consumer attitudes to nanotechnology are compared and contrasted. Results from eight national random sample surveys of adult subjects, over a five year period, are examined. 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, 2008, 2009).

Results

For Australian subjects, knowledge of “nanotechnology” steadily increased over the five years (2005-2009) with those who had “heard of the term” increasing from 51% to 74%. However most subjects (88% in 2009) stated that they were uninformed about nanotechnology; they were either unaware of the term (26%), or they “don’t know what it means” (29%), or they “don’t know how it works (33%) (MARS, 2010).

For US subjects the awareness of nanotechnology was low and witnessed only “minor shifts” over the period 2006 to 2009. In 2009, 68% of subjects had heard “little or nothing” about nanotechnology (HRA, 2009). Awareness in 2006 was 69% of respondents knowing “little or nothing” (42% “nothing”; 27% “little”) (HRA, 2006).

Despite this self-declared lack of knowledge, Australian subjects were generally positive about the prospects of nanotechnology and this was stable across the five year period, with an average 83% of respondents stating they were “excited” or “hopeful”, compared to on average 13% stating they were “”alarmed” or “concerned” (MARS, 2010). However, this positive attitude to nanotechnology applied “except for uses associated with food or some skin applications” (MARS, 2010, p.3). In each of the four surveys food was the big and the exceptional issue: “caution was often expressed about nanotechnology applications in food products” (MARS, 2010, p.9). Support for nanotechnology “Food packaging that monitors environmental conditions to prevent food spoilage” fell significantly from 74% (2005), to 70% (2009). Support for nanotechnology “Changing nutrients and vitamins in food” fell significantly from 49% (2005), to 32% (2009). The support (32%) for nanotechnology ‘enhanced’ food was comparable to levels of support for GM food (27%) and cloning (31%) (MARS, 2010).

Of five issues of concern, the one that attracted the greatest level of support (81%) was “food labelling should provide information about any nanotechnology used”; of those concerned, 58% were “greatly concerned” and 23% were “mildly concerned”. The proposition that “because nanotechnology is so new there might be problems for public safety or worker safety” attracted concern from 80% respondents, of whom 35% were “greatly concerned” and 45% were “mildly concerned” (MARS, 2010).

For US subjects the percentage of subjects who agreed with the proposition that the benefits of nanotechnology outweigh the risks was initially 20% or less, for each of the

years 2006 to 2008. The “initial impressions” of US subjects in 2008 were that 20% took the view that “Benefits outweigh risks”, and this rose to 30% for “informed impressions” after respondents were read a statement of potential benefits and risks (HRA, 2008). The corresponding figures in 2006 were 15% rising to 26% (HRA, 2006); and in 2007 18% rising to 30% (HRA, 2007); figures were not reported for 2009.

For US respondents, 12% agreed with the proposition that “I would use food storage containers enhanced with nanotechnology”; others would “need more information” (73%) or “would not use” (13%). Only 7% of respondents agreed with the proposition that “I would purchase food enhanced with nanotechnology”; others would “need more information” (62%) or “would not purchase” (29%) (HRA, 2007).

Discussion

These results suggest, firstly, that consumers are ahead of the regulators, and, secondly, that there is a general congruence between the attitudes of respondents in both the USA and Australia. Nanomaterials in food is the big issue for consumers, however, they are mostly ‘in the dark’ about what nanotechnology is and how it is being incorporated into products, there is no mandated labelling, and broad ranging nano-specific regulations do not appear immanent. Despite the consumer concern and lack of regulation, the market is ahead of both consumers and regulators, and it is rapidly commercialising research and incorporating nanomaterials into consumer products, including food and food-related products.

The US Department of Agriculture (USDA) sees nanotechnology ushering in an era of “fundamental” and “revolutionary” changes across a broad and diverse spectrum of their domain. They state that “Nanotechnology has enormous promise to bring about fundamental changes and significant benefit” (NNI, 2010, p.13). The National Institute of Food and Agriculture of the USDA state that “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” (NNI, 2010, pp.14-15).

The wariness of survey respondents to nanotechnology in general, and nanofood in particular, is corroborated by the US EPA’s conclusion: “Size can influence toxicity … Shape may also influence exposure and toxicity. We still have a lot to learn” (Jordan, 2010, p.7). Despite the optimism of the USDA, the potential for unknown health and safety issues remains unresolved and unpredictable. The ramifications of ingesting, inhaling or dermally absorbing nanomaterials is unlikely to be known for decades.

Australia, Canada, Demeter-International, and the UK’s Soil Association exclude nanomaterials in their organics standards, however most national organics standards, including those of the USA, do not address this issue. The *Australian National Standard for Organic and Bio-Dynamic Produce* appears to have been the first organic standard to exclude nanotechnology. The Australian Standard of 1 July 2007 stated that: “Products or by-products … that are manufactured/produced using nano-technology, 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 Soil Association was also an early adopter of a nano-exclusion from its organics standard, and operationalised the exclusion by providing the dual test of prohibiting: “ingredients

containing nanoparticles" where "the mean particle size is 200 nm or smaller" and "the minimum particle size is 125 nm or smaller" (SA, 2008, p.93).

Conclusions

At least four conclusions can be drawn that pertain to the organics sector. Firstly, the sector has yet to find a collective voice on nanotechnology, and, in this, it is behind (a) the handful of certifiers who have already excluded engineered nanomaterials and (b) the 'wisdom of the crowd' as revealed by surveys over five years and two continents. Sector-wide exclusions of synthetic fertilisers and pesticides, GMOs, cloning and irradiation offer precedents for a nanotechnology exclusion. For the organics sector, the issue is not about toxicology, it is about philosophy and principle - and when and how to 'meet and greet' new synthetic cryptic chemical additions to the food stream.

Secondly, surveys reveal that there is a demonstrated constituency for no-nano food; this presents an opportunity for the organics sector. Thirdly, a no-nano stance from the organics sector carries with it the attendant responsibility of maintaining a watching brief on nano developments and their infiltration into the food and agriculture sectors, so that an exclusion is actively maintained in practice, and not just 'in the standard'.

Fourthly, the tardy response of the organics sector to nanomaterials indicates that the timeliness with which the sector can respond to new technologies needs attention. A few individual certifiers have responded, but the collective response of the sector has been lacking. The rate of technological change is escalating, and the organics sector needs a mechanism geared to meet this escalation in a timely manner, proactively and prospectively, and preferably consensually and collectively.

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