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RSC response to the House of Lords Science and Technology Select Committee call for evidence on 'Nanotechnologies and Food'.

The RSC welcomes the opportunity to contribute to the House of Lords Science and Technology Select Committee call for evidence on 'Nanotechnologies and Food'.

The RSC is the UK Professional Body for chemical scientists and an international Learned Society for advancing the chemical sciences. Supported by a network of over 46,000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

If you would like further information or need anything in this document clarified, please do not hesitate to contact me.

Yours Sincerely,
Farrah Bhatti

State of the science and its current use in the food sector

1. The RSC has recently published a comprehensive report identifying the science, engineering and technological innovation that underpin food production. This report, *The Vital Ingredient*, covers the breadth of the food supply chain: Primary Agriculture, Manufacturing, Processing, Distribution, Retail, Consumer, and Waste. Nanotechnology is one of a number of existing and future opportunities for the chemical sciences to improve food sustainability and food security.

2. Hard copies of the report are available on request, alternatively it can be accessed online (www.rsc.org/thevitalingredient).

3. The RSC response will focus on the state of science, relating to nanotechnology, and its use in the food sector.

4. It is important to clarify exactly what is meant by nanotechnology and nanoparticles in relation to food. Nanomaterials have been broadly defined by the Royal Society and the Royal Academy of Engineering as having one dimension less than 100 nanometres. There are many examples of existing nanoparticles which are not new, e.g. viruses which range in size from 10-300 nm across. Manufactured nanoparticles to be added to food could involve manipulation of existing ingredients, or completely novel chemical structures. Manipulation of food at the nano-level is also not new; homogenisation of milk to prevent the natural separation of cream from the rest of the emulsion is a classic example of this.

5. Novel nanoparticles in food can be divided into soft materials (these are largely consumed) and hard surfaces (non-contact & contact applications such as processing equipment & packaging). Due to the nature of their applications, the impact on human biology is less significant for hard surface materials than soft materials; therefore the risks to human health are likely to be lower for hard surface materials.

6. In the absence of legislation and an appropriate risk assessment framework, the food industry will be liable for any new hazard. Whilst small companies and academic institutions are researching the potential of this emerging technology, commercial realisation of new products and ingredients is not being carried through to market.

What are the main potential applications and benefits of nanotechnologies and nanomaterials in the food sector, either in products or in the food production process?

7. Nanotechnology has many potential contributions to make across the food supply chain. These include noncontact sensors in food processing and packaging, new functional materials, food formulation and improvements in diet, for example increasing the content and bioavailability of micronutrients of food. New materials based on nanotechnology, with increased strength, offer the potential to reduce packaging waste by allowing down gauging of the packaging and improved thermal transfer.

What is the current state of the market for, and the use of, food products and food production processes involving nanotechnologies or nanomaterials, either abroad or in the UK?

8. Nanotechnologies are currently being used in the treatment of aqueous effluent from the food industry. Microfiltration, ultrafiltration, nanofiltration and reverse osmosis membranes are all used for water treatment, depending on the size of the molecules to be removed or recovered. Some organisations are investigating the potential to reduce beverage turbidity arising from the presence of insoluble components, particularly those that might confer a functional benefit.

What might the 'next-generation' of nanotechnologies and nanomaterials look like? How might they be applied in the food sector, and when might they enter the market?

9. Nanotechnology will provide the food industry with more capability and precision, which will in turn make processes more efficient and sustainable, both in manufacturing and in subsequent digestion. The need for mechanisms to control the delivery of functional ingredients within the body has focused on the development of nanostructures such as:

    - the use of proteins to lower fat content in emulsion-based products with no detrimental end-product organoleptic effect;
    - the use of acid-sensitive alginates that create a 'full' sensation inside the stomach, slowing down gut passage rates;
    - engineering taste sensations into high fat products or nutritional benefits;
    - nano-filtration, already applied to the filtration of microorganisms from food;
    - filtering out components such as lactose from milk and replacing it with another sugar, creating milk suitable for lactose-intolerant individuals; and
    - encapsulation systems used to provide protection against environmental factors, controlled release and nutrient delivery.

10. The use of intelligent packaging systems and technologies for the improved control of food spoilage, hygiene and food safety is a key area for further development, the emphasis being on control rather than detection. For example, there has been considerable work on developing the use of time temperature indicators, but their uptake has been limited, since detection without remedy, produces more waste.

11. Nanotechnology has potential benefits by reducing deterioration. For example, packaging based on nanotechnology that absorbs oxygen will have significant benefits on the shelf-life and eating quality of certain foods. However, such approaches cannot be applied without fully considering the microbiological impact of reducing oxygen, which may include stimulation of growth or selection for wholly or facultative anaerobic pathogens such as *Clostridium botulinum*.

12. Nanoscale film on confectionery, based on oxides of silicon or titanium with antimicrobial properties could increase the life of much manufactured food. Currently the application of such materials to food with a short shelf-life is limited by the long contact time needed to achieve the desired antimicrobial effects. Additionally, the effect of such film may be limited to that part of the food that is in direct contact with it.

13. Nanolaminates for food packaging include edible films for fruit, vegetables, meat, and chocolate baked goods. Films that provide specific protection from moisture, lipids and gases can improve the textural properties of food, and serve as carriers of colours, flavours, antioxidants, nutrients, anti-browning agents, enzymes and antimicrobials.

14. Nanoparticles could be used in printing ink, changing the colour of the label to indicate the remaining shelf-life of a perishable food, possibly replacing (with regulatory agreement) the current 'use-by date' labelling system.

15. These developments require significant technical, legal and consumer education issues to be considered before any new products enter the market.

What is the current state of research and development in the UK regarding nanotechnologies and nanomaterials which have or may have an application within the food sector? How does it compare to research and development in other countries?

16. A sufficient supply of the omega-3 fatty acids is essential for a healthy diet. Since they cannot be metabolically synthesised by humans, they can be considered comparable to vitamins. Omega-3 fatty acids, or the triglycerides containing them, can be incorporated into food products; however they must be added close to the end of the manufacturing process because high temperatures and heavy metal ions cause rapid oxidation. Another technique to protect these fats from oxidising in prepared foods is microencapsulation. This technology is already available; however current research into the formation of nanoemulsions provides further potential.[1]

17. Generally industrial research in nanomaterials is limited, although Leatherhead Food International and the Nano Knowledge Transfer Network are working with industrial consortia. There is a risk that UK developments in this area will lag behind other nations, due to fears of a repeat of the consumer resistance to other new technologies such as GM and irradiation.

What are the barriers to the development of new nano-products or processes in the food sector?

18. Barriers to the development of new nano-products or processes in the food sector include uncertainty surrounding issues of regulation, health and safety, the risks vs. benefits of the new technological developments, and consumer acceptance.

Health and safety

19. The RSC recommends looking at the following reports for information on issues of health & safety, risk assessment, and regulation:

    - Food Standards Agency 'Report of FSA regulatory review of the use of nanotechnologies in relation to food', 2008 [2]
    - Royal Commission on Environmental Pollution report, 'Novel Materials in the Environment: The case of Nanotechnology', 2008[3]
    - European Centre for Ecotoxicology and Toxicology of Chemicals workshop report 'Workshop on Testing Strategies to Establish the Safety of Nanomaterials', 2006[4]
    - The European Food Safety Authority (EFSA) scientific opinion on 'The Potential Risks Arising from Nanoscience and Nanotechnologies on Food and Feed Safety', 2009[5]

20. Furthermore, the OECD Working Party on Manufactured Nanomaterials, established in September 2006, is looking at international co-operation in health and environmental safety related aspects of manufactured nanomaterials.[6]

1 Henry J. V., Frith W. J., Fryer P. J., and Norton I. T., Kinetically Trapped Food Grade Nano-emulsions., Foods and Food Ingredients Journal, 213, 192 (2008)

2 http://www.food.gov.uk/gmfoods/novel/nano

3 http://www.rcep.org.uk/novelmaterials.htm

4 http://www.ecetoc.org/workshop-reports

5 http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902361968.htm

6 www.oecd.org/sti/nano

Regulatory framework

Is the regulatory framework for nanotechnologies and nanomaterials fit for purpose? How well are imported food products containing nanotechnologies and nanomaterials regulated?

21. This aspect is not well regulated owing to inadequate funding, the burden of import regulation falling on some individual local authorities associated with major ports, lack of validated analytical methods, and gaps on horizon scanning for risks associated with imported nanotechnologies and nanomaterials.

How effective is voluntary self-regulation either in the UK or EU or at an international level? What is the take up by companies working in the food sector?

22. No comment

Will current regulations be able adequately to control the next generation of nanotechnologies and nanomaterials?

23. This depends on any gross differences in the toxicity of nano materials. As always the first step is to determine the intrinsic toxicology of the "parent" material itself and then look to see if reducing the particle size down to the nano scale changes the toxicological profile.

Is there any inter-governmental co-operation on regulations and standards? What lessons can be learned from regulatory systems in other countries?

24. EFSA is actively engaged in coordinating European risk assessment to feed into potential Commission regulation of nanotechnologies and nanomaterials.[7] The OECD is also working in this area.[6]

Public engagement and consumer information

What is the current level of public awareness of nanotechnologies, and the issues surrounding the use of nanotechnologies and nanomaterials in the food sector? What is the public perception of the use of such technologies and materials?

25. The last major study into public attitudes towards nanotechnologies in the UK was carried out in 2004 by the market research company BMRB International:[8]

    - The results of the opinion poll, carried out by BMRB for the Royal Society and Royal Academy of Engineering joint working group on nanotechnology, showed that 29% of the public claim they have heard of nanotechnology, while only 19% are able to give some definition of it. Of those who are able to offer a definition of nanotechnology, 68% said it would make things better in the future.
    - Participants drew a parallel with GM when considering the ethical implications of nanotechnology because of the perception that both involve changes at the most fundamental level to form something that does not occur in nature. Both GM and nanotechnology could be seen as "messing with nature" in a specific way by "manipulating the building blocks of nature". They expressed concerns about whether scientists are trying to "play God".
    - Participants were very positive towards potential uses of nanotechnology in medicine, particularly in terms of earlier diagnosis and treatments. However, they also had concerns about the long-term potential side-effects of nanotechnology, and about its reliability.

[7] http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902132298.htm
8 http://www.nanotec.org.uk/MR1.htm

26. Public opinion may have changed in the last five years, and it would be worthwhile to repeat this study. Indications from the USA are that the public are more accepting of nanotechnologies in the last two years. Consumers are more likely to embrace technology when they can see a clear benefit for them (as shown by the more positive attitude towards nanotechnology in medicine). Public attitude in the UK may have grown to be more positive in recent years if the benefits of nanotechnology in food (e.g. reduction of food waste, improved nutritional content of food, and cost of food) have become clearer.

How effective have the Government, industry and other stakeholders been in engaging and informing the public on these issues? How can the public best be engaged in future?

27. Feeding emerging scientific areas, such as nanotechnology, into the communication and engagement process should be done at an early stage, as exemplified by the nanodialogues (experiments in upstream public engagement), led by Demos, and part-funded by the government in 2005-2007. As a result, EPSRC recently included a public dialogue on nanotechnology to help develop its funding call in this area.[9]

28. Failure of consumer acceptance can also be guarded against by well informed and robust regulation safeguarding consumers while promoting innovation. However, this will require funding for research into fit for purpose detection systems and deeper insights into the toxicology of engineered nano-products.

What lessons can be learned from public engagement activities that have taken place during the development of other new technologies?

29. People are often suspicious of new technologies because they are concerned that corporate profits may come before public safety. Thus, with the introduction of any new technologies, there must be an early dialogue involving effective communication of the benefits as well as risks to the consumer and/or the environment.

30. This was done effectively by Sainsbury and Safeway supermarkets when they started to sell Zeneca's GM processed tomatoes to their customers in 1996.[10,11] The products were clearly labelled as GM and consumers were given a free choice as to whether or not to buy the GM tomato product. Consequently, consumers tried the new tinned tomato puree and sales started to grow.

31. The "climate" around GM changed primarily due to concerns that the USA would not segregate their GM soya and maize from their non-GM counterparts, thus removing choice from the consumer.[12]

32. One of the problems for companies promoting GM crops was that the consumer did not see the benefits and were not offered choice. This is in contrast to the use of GM in the pharmaceutical industry, where benefits to the public are much more obvious. Similarly, any situation which reduces consumer choice should be avoided.

9 http://www.epsrc.ac.uk/Content/News/PublicDialogueonNanotechnologyforHealthcare.htm

10 http://www.ncbe.reading.ac.uk/NCBE/GMFOOD/tomato.html

11 http://www.agbioforum.org/v4n1/v4n1a11-tait.htm#R3

12 http://www.supra.ed.ac.uk/Publications/paper14.pdf

Should consumers be provided with information on the use of nanotechnologies and nanomaterials in food products?

33. Consumers are often bombarded with large amounts of conflicting information about climate change, the environment, and new technologies in food production and waste disposal; and it is very difficult for them to make balanced judgements. There must be a balance of providing the relevant information necessary for consumer choice, and bombarding the consumer with unnecessary detail. However, the balance must be in favour of information being made available to consumers. This information should be presented in a standardised form. Emerging technologies will facilitate this, for example point of sale information in addition to that available on a food label could be made available via mobile telephones, barcode scanners, wifi devices and similar innovative information rich streaming facilities. Websites can provide much more detailed information particularly to shoppers using the internet.