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Awareness and attitudes towards the emerging use of nanotechnology in the agri-food sector

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ABSTRACT

Nanotechnology has relevance to applications in all areas of agri-food including agriculture, aquaculture, production, processing, packaging, safety and nutrition. Scientific literature indicates uncertainties in food safety aspects about using nanomaterials due to potential health risks. To date the agri-food industry's awareness and attitude towards nanotechnology have not been addressed. We surveyed the awareness and attitudes of agri-food organisations on the island of Ireland (IoI) with regards to nanotechnology. A total of 14 agri-food stakeholders were interviewed and 88 agri-food stakeholders responded to an on-line questionnaire. The findings indicate that the current awareness of nanotechnology applications in the agri-food sector on the IoI is low and respondents are neither positive nor negative towards agri-food applications of nanotechnology. Safer food, reduced waste and increased product shelf life were considered to be the most important benefits to the agri-food industry. Knowledge of practical examples of agri-food applications is limited however opportunities were identified in precision farming techniques, innovative packaging, functional ingredients and nutrition of foods, processing equipment, and safety testing. Perceived impediments to nanotechnology adoption were potential unknown human health and environmental impacts, consumer acceptance and media framing. The need for a risk assessment framework, research into long term health and environmental effects, and better engagement between scientists, government bodies, the agri-food industry and the public were identified as important.

1. Introduction

Nanotechnology is the manipulation of materials and structures at sizes in the nanoscale range, approximately between 1 and 100 nm (European Food Safety Authority, 2009). Nanotechnology research is attracting large scale investments by leading producers of agricultural and food products with some food, beverage and packaging products that incorporate nanotechnologies already commercially available in certain countries (Gruère, 2012; Momin, Jayakumar, & Prajapati, 2013). Applications of nanotechnology are relevant to all areas of food science (Fig. 1), including agriculture, food processing, packaging, safety, nutrition and nutraceuticals (Agrawal, & Rathore, 2014; Araújo et al., 2013; Chaudhry & Castle, 2011; Chaudhry et al., 2008; Duncan, 2011; Durán & Marcato, 2013; Ezhilarasi, Karthik, Chhanwal, & Anandharamakrishnan, 2013; Sozer & Kokini, 2009; Kalpana Sastry, Anshul, & Rao, 2013; Momin et al., 2013; Mousavi & Rezaei, 2011; Rashidi & Khosravi-Darani, 2011; Sekhon, 2014). It is anticipated that nanotechnology will bring significant benefits to the agri-food industry and consumers including more efficient food production methods, the development of functional foods which offer health claims, increased shelf life of food products, more hygienic food processing, and improved traceability and safety of products (Chaudhry & Castle, 2011; Ranjan et al., 2014). Nanofoods and nanopackagings have already been commercialised in some countries; these are identified in the Project on Emerging Nanotechnologies (PEN), Consumer Products Inventory (http://www.nanotechproject.org/cpi/), though this list is not definitive. For example, Shemen

Abbreviations: GM, Genetic Modification; IoI, Island of Ireland; NI, Northern Ireland; ROI, Republic of Ireland; SME, Small and medium enterprise.

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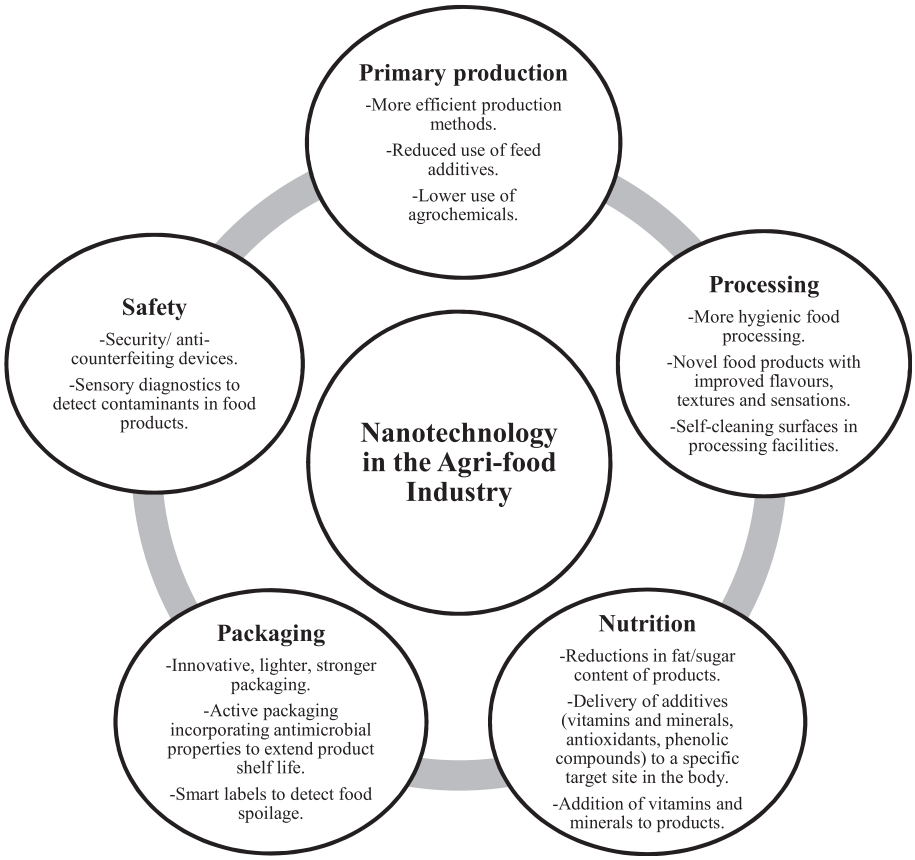

Fig. 1. Identification of key emerging themes from the systematic review (Handford, Dean, Henchion, et al., 2014); applications of nanotechnology in the agri-food industry.

Industries have incorporated nanoparticles into their Canola Active Oil to enable penetration of healthy components (such as vitamins), while Voridan has developed a nanocomposite to be used in their beer bottle plastics to make them harder and stronger.

It is difficult to know how widespread the application of nanotechnology is in the agri-food sector because there is limited research on the industry's actual awareness of nanotechnology or how it is being applied. The industry's awareness and attitudes towards the use of nanotechnologies for agri-food applications have not been explored so far. Nevertheless, an organisation's willingness to adopt such technologies is likely to be dependent on a number of factors including existing uncertainties relating to health and safety, with indications that the incorporation of nanomaterials into food products and packagings may present an entire new array of risks for consumers (Bouwmeester et al., 2009; Bradley, Castle, & Chaudhry, 2011; Cockburn et al., 2012; Han, Yu, Li, & Wang, 2011; Ileš, Martinovic, & Kozak, 2011; Kuzma, Romanchek, & Kokotovich, 2008; Magnuson, Jonaitis, & Card, 2011; Magnuson et al., 2013; Silvestre, Duraccio, & Cimmino, 2011). Further, at present, there is little regulation regarding nanotechnologies or nanoproducts (Coles & Frewer, 2013). Only a few government agencies from different countries have established regulatory frameworks for the use of nanotechnology; these are considered to be extensive enough to cover agri-food applications (Mantovani, Porcari, Morrison, & Geertsma, 2011). Further, consumers are found to be more accepting of packaging (nano-outside) than products that incorporate nanomaterials within the food (nano-inside) which they consider to be more risky (Frewer et al., 2011; Henchion et al., 2013; Ravichandran, 2010; Siegrist, Cousin, Kastenholz, & Wiek, 2007; Siegrist, Stampfli, & Kastenholz, 2009). Finally, organisational issues are thought to be an impediment to the adoption of nanotechnologies; for small and medium enterprises (SMEs), innovation may be constrained by limited resources and difficulties to access research and know how to implement such technologies (Nooteboom, 1994; Trail & Grunert, 1997). This is highly relevant on the island of Ireland (IoI) where the vast majority of agri-food organisations are SMEs (>90%) (Teagasc, 2009).

The present study aimed to investigate (i) the agri-food industry's awareness and attitudes towards nanotechnology and applications, (ii) the industry's current usage of nanotechnology, (iii) the perceived risks and benefits of nanotechnology in relation to food, (iv) nanotechnology opportunities and (v) obstacles to the adoption of nanotechnologies across the IoI. It was anticipated that this study could be used as a measure of the importance of nanotechnology to the European agri-food sector through the inclusion of multinational corporations.

2. Methods

2.1. Interviews and electronic questionnaires

Informed by a systematic literature review (Handford, Dean, Henchion, et al., 2014; Handford, Dean, Spence, et al., 2014), executive interviews were conducted with key stakeholders to explore the research objectives. This was complimented by an on-line survey administered to a wide range of stakeholders to enable quantification of several issues. All responses were given from an organisational perspective not the respondent's own. The systematic review involved a search of the commercially available electronic databases PubMed, Scopus and Web of Science (ISI) for