

# International Handbook on Regulating Nanotechnologies

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## 15 Regulatory perspectives on nanotechnologies in foods and food contact materials

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### 15.1 INTRODUCTION

The convergence of nanotechnologies with the food sector is anticipated to transform the industry. Significant economic growth is expected from the development and commercialization of processing technologies, nanostructured food ingredients, additives, delivery systems, and a range of food contact materials (FCMs) incorporating nanoparticles (Chaudhry et al., 2008; European Food Safety Authority, 2008). The latter application area makes up ‘the largest share of current and short-term’ predicted markets for nanotechnology applications for the food sector (Cientifica, 2006). Helmut Kaiser Consultancy (2004) has suggested that the nano-food sector will, by the year 2010, be worth in excess of \$US20 billion per annum. These purported unrivalled possibilities explain the significant hype surrounding nano-foods at present. Arabe (2002) has, for instance, predicted that future nanotechnology applications will include smart foods utilizing functional encapsulation of active nanoparticles, filters that may modify flavours or remove toxins, and smart packaging that can detect the spoiling of foods.

Against this backdrop of industry-driven activities, there is a clear need to determine the extent to which nanotechnology products and applications fall within existing regulatory frameworks, and the adequacy of these frameworks for managing potential risks. This has given rise to a number of governments around the world initiating either in-house or independent reviews. Many of these have either focused on, or at least included within their scope, the impact of nanotechnology in the agri-food sectors (see, for example, Chaudhry et al., 2006; Food Standards Agency, 2008; Ludlow et al., 2007; Food Safety Authority of Ireland, 2008; European Commission, 2008a, 2008b; House of Lords, 2010). Common to each of these reviews has been the conclusion that the majority of current and near-term nanotechnology products and applications will fall within the scope of

conventional regulatory regimes. In the view of the European Commission (2008a: 3), for example, ‘. . . it can be concluded that current legislation covers to a large extent risks in relation to nanomaterials and that risks can be dealt with under the current legislative framework’. Accordingly, while the European Commission (2008a) notes that legislation may have to be modified over time to deal with the evolving scientific state of the art, the main issue is around the implementation of the legislation itself and not its scope.

This view has been heavily criticized by the European Parliament. In a resolution of April 2009, which was initiated by the Parliament’s Committee on the Environment, Public Health and Food Safety in January 2009, the European Parliament (2009) stated that it

does not agree, before an appropriate evaluation of current Community legislation, and in the absence of any nano-specific provisions therein, with the Commission’s conclusions that a) current legislation covers in principle the relevant risks relating to nanomaterials, and b) that the protection of health, safety and the environment needs mostly be enhanced by improving implementation of current legislation, when due to the lack of appropriate data and methods to assess the risks relating to nanomaterials it is effectively unable to address their risks.

The Members of European Parliament (MEPs) overwhelmingly voted in favour of, for example, in-depth reviews of Community laws and their applicability to nanotechnologies and called for greater transparency in the use of nanomaterials in consumer products (European Parliament, 2009b).

This chapter aims to assess the adequacy of the European Union’s current regulatory frameworks for managing the potential risks posed by food and food packaging applications incorporating nanotechnologies. Such a review is timely given the dynamic nature of the European regulatory environment, including the proposal of the European Commission for a new Regulation on novel foods (COM(2007) 0872 final), which will repeal Regulation (EC) No. 258/97.<sup>2</sup> The proposal expressly includes in the Preamble ‘foods modified by new production processes, such as nanotechnology and nanoscience, which may have an impact on food’ as novel foods. Furthermore, the EU legislators have recently agreed on the introduction of new authorization procedures for food additives, food enzymes and food flavourings (Regulation (EC) No. 1331/2008), which has similarly an impact on the adequacy of the regulatory regime. Along with the regulatory developments in the EU, this chapter also examines relevant regulatory frameworks within the United States and Australia. Inadequacies and gaps within these instruments are considered in light

of the current state of the art in terms of both science and law. Finally, in acknowledging the delicate balance between promoting innovation while taking reasonable precautions in order to protect public health and the environment, the chapter articulates a range of mechanisms that could be adopted to assist governments in achieving this fine balance.

## 15.2 EUROPEAN UNION

### **General Food Safety and Consumer Health Protection**

EC Food Law Regulation 178/2002 sets down the general principles and requirements of food law within the EU. The regulation provides for the establishment of the European Food Safety Authority (EFSA) (Article 22), sets down the procedures in matters of food safety, and hence provides the basis for the assurance of a high level of protection of human health and consumers' interest with respect to food.

Pursuant to Article 14(1), food cannot be placed on the market 'if it is unsafe'. Moreover, it is ineligible for marketing if it contains substances harmful to health. Due to the all inclusive scope of Regulation 178/2002, the general safety articles embodied therein will, by implication, also encompass foods containing nanomaterials and/or manufactured using nanotechnologies. Consequently, the notion of traceability of nanomaterials as food ingredients or additives is covered under the existing requirements of Regulation 178/2002.

Besides the Food Law Regulation and its general safety criteria, EU legislation of particular relevance to nanoscale food ingredients is Regulation (EC) 258/97 concerning Novel Foods and Novel Food Ingredients. This regulation establishes a mandatory premarket approval system for all novel foods. According to the European Commission (2008b: 21–2):

Regulation 258/97 allows assessing possible risks associated with the use of nanomaterials and nanotechnologies (novel food ingredients) and nanotechnologies (novel technology with impact on food) in relation with food and food ingredients.

This regulation is currently under review, and will be replaced with a new regulation which

aims to streamline the authorization procedure, develop a more adjusted safety assessment system for traditional food from third countries . . . and clarify the definition of novel food, including new technologies with an impact on food (European Commission, 2008c: 2).

As the final text of the recast of the regulation has yet to be adopted, this chapter will focus on the current regulatory framework; reference will, however, be made to the proposed regulation due to the express inclusion of 'nanotechnology and nanosciences' within its text.

Pursuant to Article 1 of Regulation 258/97, a 'novel' food is defined as a food or food ingredient not having a significant history of human consumption within the Community prior to May 1997 and which falls within one of several defined categories. The categories that may have relevance to nanotechnologies include:

- 'foods and food ingredients with a new or intentionally modified primary molecular structure' (Article 1(c) Regulation 258/97), and
- 'foods and food ingredients to which has been applied a production process not currently used, where that process gives rise to significant changes in the composition or structure of the foods or food ingredients which affect their nutritional value, metabolism or level of undesirable substances' (Article 1(f) Regulation 258/97).

Considering the current and projected applications of nanotechnologies in food, it is unlikely that most nano-structured food products (at least in the foreseeable future) would fall under the first category, that is, they would not necessarily have a different molecular structure compared to normal processed food. Rather the foods would be 'enhanced' or 'modified' than being different at the molecular level, though this possibility cannot be ruled out. There is, however, a stronger and more immediate likelihood that they would fall under the second category, providing that the attached caveat is fulfilled. The onus for recognizing that a food substance falls under the latter category and alerting the competent food assessment body lies with the person responsible for placing the product on the market. However, in the case of nano-structured foods, Regulation 258/97 would only appear to be applicable if a substance was regarded both as 'novel' and its nutritional value, metabolism *or* level of undesirable substances was substantially altered compared to its macro-scale counterpart.

If the company responsible for placing a nanofood product on the market did not recognize it to be novel<sup>3</sup> and/or did not consider the properties of the nanofood to be substantially different from its macro-scale counterpart,<sup>4</sup> then it is possible that a safety evaluation under Regulation 258/97 would not be carried out. This means that the caveat attached to the definition of this category of novel foods under the current regulation leads to some uncertainty over whether a nano-structured food product

falls into this category or requires testing to show that their nutritional value, metabolism or level of undesirable substances have not been affected. It is also unclear whether this regulatory framework would apply to food ingredients that have a significant history of use but may already be marketed (by chance, not by design) in forms that contain particle sizes of 100 nm or less.

The proposed recast of the regulation provides the EC with a unique opportunity to address the current ambiguities of Regulation 258/97, especially in relation to nanofood products. Under the final draft proposal, published in January 2008, the definition of a ‘novel food’ was altered so as specifically to include

food to which is applied a new production process, *not used before 15 May 1997*, where that production process gives rise to significant changes in the composition or structure of the food which affects its nutrition value, metabolism or level of undesirable substances [emphasis added] (Article 3(2)(iii), European Commission, 2008c).

A new production process is defined in the Preamble (6) so as expressly to include ‘foods modified by new production processes, such as nanotechnology and nanoscience’ (European Commission, 2008c). What is meant by ‘nanotechnology and nanoscience’ is not defined in the current proposal. However, as with Regulation 258/97, the proposed regulation applies only if the food’s nutritional value, metabolism profile, or the level of undesirable substances was substantially altered relative to its macro-scale counterpart. Only when both criteria are fulfilled would the food be considered to be ‘novel food’ for the purposes of a pre-market safety evaluation and require listing on the proposed community list of novel foods (European Commission, 2008c). A recently published report by the UK House of Lords Science and Technology Committee on Nanotechnologies and Food recommends that ‘any regulatory definition of nanomaterials proposed at a European level, in particular in the *Novel Foods Regulation*, should not include a size limit of 100 nm but instead refer to “the nanoscale” to ensure that all materials with a dimension under 1000 nm are considered’ (House of Lords, 2010: 50).

### **Regulatory Aspects Relating to Nanoscale Food Additives**

Since early 2010 the use of food additives has been controlled by a common authorization system, as the European Community has adopted a set of Regulations that provide for a common basis of controls on food additives (Regulation (EC) No. 1333/2008), food enzymes (Regulation (EC) No. 1332/2008) and food flavourings (Regulation (EC) No.

1334/2008). The adoption of the common authorization procedure brings together all existing food additive regulations and introduces comitology for the approval of the three categories of substances.

In line with the decision to separate risk assessment and risk management, under the new system, all applications for the approval of each category of substance will be directed to the EFSA, who will carry out the safety evaluations and risk assessments. Pursuant to the new regulations, a positive-list ('Community list') will be established for each substance category. As noted by the European Commission (2007: 3), 'the inclusion of a substance on one of these lists means that its use is authorised in general for all operators in the Community'.

The most relevant aspect in relation to the use of nano-scale food additives in the new regulation is arguably the re-evaluation of safety assessment, which will ensure that food additives, once permitted, are kept under continuous observation and re-evaluation. Therefore, under the new regulation, producers or users of food additives which are 'significantly different from those included in the risk assessment of the Authority or different from those covered by the specifications laid down' will be obliged to inform the Commission of any new information that may affect their safety assessment. As stated in the new regulation, a 'significant difference' could mean, *inter alia*, 'a change of the production method from extraction from a plant to production by fermentation using a micro-organism or a genetic modification of the original micro-organism, a change in starting materials, or a change in particle size, including the use of nanotechnology' (see Preamble 12 of Regulation (EC) No 1332/2008). Based on the definition, the use of nanotechnology will constitute a 'significant different' method for the purposes of re-evaluation by the EFSA, and is an important inclusion in the new regulation. Moreover, under the new regulation, the EFSA will also be invested with the power to re-evaluate a food additive on the basis of 'new scientific information' (Preamble 14 of Regulation (EC) No. 1332/2008). While it is unclear at this time whether or not 'new scientific information' would be interpreted so as to include development in nanotechnologies, it is argued that the express inclusion of 'change in particle size' in Regulation (EC) No. 1332/2008 may be relevant for triggering re-evaluation by the EFSA.

A potential limitation of the new regulatory regime in relation to the use of nanoparticles appears to be the current lack of information to describe adequately the food additive; that is, to ensure that in all relevant aspects that correspond to the additive that have been assessed for safety. While it is provided that the previous food additive specifications will be maintained until the corresponding additives are entered into the annexes

of any new regulation, there are as yet no criteria within the proposed specifications that cover the use of nanoparticles per se.

### **Regulatory Aspects Relating to Food Contact Materials ('FCMs')**

FCMs are subject to the requirements of Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food (the 'Framework Regulation'). Article 3 of the Framework Regulation requires that all FCMs be manufactured in accordance with good manufacturing practice so that, under normal or foreseeable conditions of use, they do not transfer their constituents to food in quantities that could endanger human health, bring about an unacceptable change in the composition of food, or deteriorate the organoleptic characteristics of food.

This means that substances not covered by other, obligatory requirements may be used today in FCMs in compliance with applicable EU legislation, provided that they are safe for their intended use and that these substances and the finished products in which they are used comply with the applicable European and national legislation of the Member States in which they are marketed, subject to the principle of mutual recognition.<sup>5</sup>

The most straightforward way of demonstrating that a substance used in the manufacture of FCMs complies with the general safety requirements of Article 3 of the Framework Regulation is to establish that it is covered by an applicable listing and that it is used in accordance with the potential restrictions that may be established for the substance in that listing. The listing of a substance as a permitted component of plastics under the Plastics Directive for instance presupposes a review and determination by the EFSA or its predecessor the EU Scientific Committee on Food (SCF) that the substance could be considered safe in the applications of interest provided potentially applicable restrictions are met.

Hence, under the existing regulatory scheme all FCMs have to be safe for the intended application in all conditions.

Nanomaterials when used in food contact applications do fall under these same requirements; that is, independent of an existing potential clearance for the bulk analogue, the intended use of the nanoform as a FCM should be demonstrated to be safe. As described above, the demonstration of safety is the duty of the manufacturer, hence it is the manufacturer's responsibility to provide packaging materials using nanotechnology, which can be proven to be safe in the intended applications. According to Article 16 of the Framework Regulation, there is a requirement on the declaration of compliance, requiring that materials and

articles for which specific measures have already been established (such as plastics) should be accompanied by a written declaration stating that they comply with the rules applicable to them. The appropriate documentation proving this compliance shall be available to the competent authorities on demand. For applications where specific measures do not yet exist, Member States may retain or adopt national provisions for demanding declarations of compliance for materials and articles. This means that explicit provisions exist already in the Framework Regulation which demand that materials and articles used in food contact applications are to be demonstrated to be safe and suitable for the intended use on a case-by-case basis. If the safety of a material is not fully known, its use can only be demonstrated to be safe if there is information to document the lack of migration and/or exposure to the substance at any toxicologically significant level. Consequently, the manufacturers and users of nanomaterials or any products of nanotechnologies in food contact applications have to either:

1. have sufficient toxicological information on the nanomaterial to demonstrate safety to human health, or
2. be able to demonstrate the lack of migration to prove that the intended use will not result in the transfer of these constituents to food in quantities that could endanger human health, bring about an unacceptable change in the composition of food, or deteriorate the organoleptic characteristics of food.

The present annexes to the Plastics Directive contain a few hundred of such ‘cleared’ substances, including monomers and additives which the Commission has authorized for use in specific food contact plastics applications following the risk assessment performed by EFSA. Importantly, the Preamble to the directive declares that

... the establishment of a list of approved substances accompanied by a limit on overall migration and, where necessary, by other specific restrictions will be sufficient to achieve the objective laid down in Article 2 of Directive 89/109/EEC (the present Article 3 requirements of the Framework Regulation).

On that basis for substances already listed in the annexes of the directive it seems to be sufficient to only adhere to the potential restrictions and as such compliance with the general safety requirements of the Framework Regulation is guaranteed.

Some of these authorized substances, however, may exist or be manufactured in nanoforms and – as the size was not a characteristic in the past which triggered any specific regulatory attention – almost no restrictions

exist today that relate to the particle size of authorized materials. On that basis it can be expected that companies – relying lawfully on the authorization of a substance as a food contact additive (based on a petition covering its bulk form) – would claim to use the nanoform in full compliance with the existing regulatory requirements. Indeed, the above cited statement from the Preamble seems to pre-empt the need to demonstrate safety by any other way when a listed substance is used in permitted applications observing the restrictions of that listing.

However, communications from Commission officials including the draft recast of the Plastics Directive suggest that using a material in its nano form on the basis of its listing in bulk form is not acceptable and the nano version would require a new separate safety assessment (on the basis that it has been produced by a different process than that used for conventional material). This position, if consequently applied, would result in the very difficult task of establishing whether a new physical form of a substance should be considered ‘nano’ and requiring further petitioning. This will be particularly difficult given that there is no common agreement of how ‘nano’ can be defined and what are the very characteristics that make the behaviour of a nano material so different from its bulk counterpart.

Nonetheless, there is one general provision in the Framework Regulation which reassures that relying on an existing authorization of a bulk substance would not facilitate the irresponsible use of its nanoform. Indeed, Article 11(5) of the Framework Regulation provides that

The applicant or any business operator using the authorized substance or materials or articles containing the authorised substance shall immediately inform the Commission of any new scientific or technical information, which might affect the safety assessment of the authorised substance in relation to human health. If necessary, the Authority shall then review the assessment.

It can be argued that using a nano form of an authorized substance may be covered by this provision, possibly obliging the user/manufacturer of the nanoform to inform the Commission of the application, if potentially there is new scientific or technical evidence questioning the safety of the nanoform in comparison with its bulk equivalent.

As described earlier, the legislation for FCMs is only partially harmonized; the evaluations by EFSA are only mandatory for monomers, other starting substances and, since 1 January 2010, additives used to manufacture FCMs made entirely of plastics. This means that in these applications no substance can be used – in nano or in bulk form – unless its risk has been assessed by the EFSA and its intended use authorized, including possibly substances on the positive list of permitted substances

with the appropriate restrictions. This interpretation is urgently calling for:

1. clarifying the confusion of relying on existing authorization for bulk substances, potentially supported by the scientific belief of the manufacturer that the use of the substance in nano form would not compromise the safety evaluation, and
2. developing proper criteria for the safety evaluation of nano materials allowing their petitioning and appropriate listing as authorized substances in food contact plastic applications.

These action items are, however, too demanding in the framework of the current authorization procedure. Today, if following the evaluation of a detailed submission on potential migration of the petitioned FCM in the intended applications and the documented toxicology of the substance, the EFSA concludes that the use of the material is safe, it recommends to the Commission the inclusion of the substance on the positive list of permitted substances. The Commission may follow the risk assessment of the EFSA and update the appropriate annexes of the directive listing the evaluated substance with the appropriate restrictions on use level/maximum migration limit (specific migration limit, or SML) and other relevant restrictions.

Under the present rules, any future manufacturer and user of the substance can then rely on this authorization, provided the restrictions are correctly observed. As future manufacturers have no information on the description of the substance and its use conditions as submitted by the petitioner other than those specifically listed as specifications and/or restrictions, they are even theoretically not in the position to properly judge whether or not relying on an existing listing goes beyond what the safety evaluation of the substance has actually addressed. The other side of this same token is that when the EFSA concludes the risk assessment for a substance and the Commission issues the relevant restrictions for its use, they have to foresee all other potential uses – and possibly, misuses – of the substance by future users who would only need to comply with the restrictions as worded by the regulators. This is clearly a huge responsibility for the authorities and can only be possibly handled by ‘over-regulating’ the substance and going much beyond its potential impact required by the application as petitioned.

The risk assessment for nano materials may require a break with this existing approach. It is not feasible scientifically to regulate different applications via general restrictions established on the basis of certain limited testing for one specific application, which is claimed to be ‘representative’.

This is because we may not know enough about the behaviour and effects of nanoparticles, and therefore, we may be unable to extrapolate information gained on one specific nanomaterial to another application. Moreover, we also do not understand what are the specific characteristics of a nanoparticle which need to be kept under control and observed as a restriction. Listing a nanoparticle on the positive list on the basis of one petition describing one specific use is scientifically probably not supportable, hence the authorities may need to re-think the applicability of a general positive list-based system for food contact applications involving nanotechnology altogether.

Instead, as for other food contact applications where the positive list system has not yet been developed into a harmonized system, the safety of the application should be established on a case-by-case basis, using sound scientific principles based on relevant data on toxicology vs. exposure and resulting in an application-specific proprietary clearance for the actual application in question.

### 15.3 UNITED STATES

#### **General Food Safety and Consumer Health Protection**

The US legislative instrument of most relevance to this chapter is the Federal Food, Drug and Cosmetic Act (the FDC Act), which is administered by the Food and Drug Administration (FDA).<sup>6</sup> The FDA also has jurisdiction over other product categories, including drugs, devices and cosmetic products. In relation to foods, the FDA – through its Center for Food Safety and Applied Nutrition – is required by law to ensure that foods that fall within the regulatory scope of the FDC Act are safe. Pursuant to the definition of a food as set out in s.201(f) of the FDC Act,<sup>7</sup> this includes whole foods, food additives, dietary supplements,<sup>8</sup> ‘generally recognized as safe’ (GRAS) food ingredients, and FCMs. This is achieved through pre-market authorization requirements for food and colour additives, with the safety of dietary supplements and GRAS food ingredients regulated through post-market oversight mechanisms. Unsurprisingly, the FDC Act does not specifically refer either to the use of nanotechnologies as a process or the inclusion of nanoscale ingredients in foods or FCM. However, as noted by the FDA Taskforce itself, the general nature of the FDC Act and most of the subsidiary act enforced by the FDA (2007: 4), ‘are general in nature by design . . . offering flexibility to accommodate products made with new technologies or containing new kinds of materials’.

The adequacy of the FDA’s existing regulatory framework with regards

to nanotechnologies across each of the product categories it regulates, including foods, has been assessed by Taylor (2006, 2008) and the FDA Taskforce (2007). Taylor's (2006: 51) analysis of the FDA's framework and resourcing led him to conclude that 'while the FDA has most of the legal tools it needs to regulate most of the products of nanotechnology, significant gaps in authority remain'. In relation to food this included, for example, a lack of power to acquire information pertaining to new nano-foods (Taylor, 2006). In their opinion, the FDA (2007: iii) believed that for product categories subject to pre-market approval, including food and colour additives, 'the agency's authorities are generally comprehensive'; the adequacy of the framework was not, in their view, altered by the use of nanotechnologies in processing or the presence of nanoscale ingredients. However, for products not subject to pre-marketing authorization processes, including whole foods, dietary supplements, and GRAS food ingredients, the agency noted that its 'oversight capacity [was] less comprehensive' (FDA, 2007: iii). In recognition of the current lack of knowledge and regulatory challenges potentially posed by some categories and their incorporation of nanotechnologies, the FDA Taskforce made a number of recommendations pertaining to data requirements and regulation perspectives. Given the breadth of these two reports, this chapter does not provide an in-depth analysis of the framework.<sup>9</sup>

### **Regulatory Aspects Relating to FCMs Produced by Nanotechnologies**

The regulatory status of FCMs under the FDC Act is codified in Title 21 (Food and drugs), Chapter 9. It is based on the general safety requirements for food, as described above. Based on these requirements, as implemented notably by the pre-market approval process, FCMs are also placed under the responsibility of the FDA. More specifically, the FDC Act prohibits the adulteration of food, and deems all substances that are intended, or may reasonably be expected, directly or indirectly, to become components of food or affect its characteristics, including FCMs, to be food additives. Food additives are automatically deemed to be unsafe and to cause food to be adulterated, unless the intended use of these substances is permitted under FDA's food additive regulations, found in Title 21 of the Code of Federal Regulations (21 C.F.R.). Various exemptions from FDA's pre-market approval requirement are included in the FDC Act as implemented by FDA's regulations and case law, so that components that are not specifically listed as permitted for food contact applications in 21 C.F.R. may still be used in compliance with the FDC Act and FDA's food additive regulations within the scope of these exemptions.

The use of any substance in a food contact application remains first and

foremost subject to the general safety requirement of the FDC Act, reinforced by FDA's GMP regulation, 21 C.F.R. § 174.5(a)(2), which requires any food contact substance to be of a 'purity suitable for its intended use', and demands that the potential level of migration into food of any component of a FCM to be safe. Safety is defined in the food additive regulations as 'reasonable certainty in the minds of competent scientists that the substance is not harmful under the intended conditions of use' (see 21 C.F.R. § 170.3(i)). We note that while Section 409(c)(3)(A) of the FDC Act establishes that no food additive shall be deemed by FDA to be 'safe' if the additive is found 'to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of safety of [the additive], to induce cancer in man or animal', this general prohibition on the use of carcinogenic additives only applies to the 'substance that is actually intended for use in food or for food contact', while all 'non-functional chemicals present in that substance would be called the 'constituents' of the additive' (see 21 C.F.R. § 170.3(i)). Such constituents include impurities, residual reactants, intermediates, manufacturing aids, and the products of side reactions and chemical degradation. Based on this distinction between the 'food additive' and its 'constituents', FDA may permit the use of an additive that is non-carcinogenic if it contains 'safe' levels of carcinogenic constituents.

In order to highlight the scope of the current US federal regulatory framework for food packaging products produced by nanotechnologies and the implications thereof, the Project on Emerging Nanotechnologies and the Grocery Manufacturers Association initiated a study which was designed specifically to

build understanding of how the regulatory process would apply to nanotech food-packaging materials and to identify issues that need to be addressed to ensure the process works effectively (Taylor, 2008: 5).

In order to determine how the system would operate when faced with nanoscale substances in food packaging, three high level working groups<sup>10</sup> developed three hypothetical food packaging products which were subsequently employed to evaluate the regulatory process. The case studies included:

- an 'active packaging product' with functionalized antimicrobial nanoparticles
- a 'smart packaging product' which incorporated nano-biosensors, and
- a product for carbonated beverages with superior barrier properties.<sup>11</sup>

Having noted the inherent complexities and challenges of the current regulatory regime, the study found that

the most challenging issues related to how the scientific and technical criteria for evaluating the food-safety aspects of ENMs [engineered nanoscale materials] in food packaging will apply, in light of their novel properties. The few legal or policy issues also stem from the science (Taylor, 2008: 6).

The legal issues were found to include, for example:

- the applicability of existing clearance instruments, such as food contact notifications and other positive lists, to nanoscale versions of existing food contact substances (when such instruments do not expressly refer to particle size)
- the applicability of the GRAS framework for food packaging containing nanoparticles both now, and in the medium term
- the applicability of food additive petitions for ensuring the safety of such products prior to the product's entry onto the market, and
- definitional issues as to what constitutes 'nanoscale' for the purposes of the regulatory framework (Taylor, 2008).

The study highlighted a significant number of knowledge gaps which are hampering regulatory and scientific efforts in the area, but also the number of regulatory ambiguities which exist within the framework. The value of such an exercise can be very valuable, as at this early stage such an endeavour provides government, regulators and industry with the insights as to what information and action is required on their part to ensure the safe and responsible commercialization of such products. Such lessons are not only relevant to the US context, but also other jurisdictions grappling with similar questions and concerns.

## 15.4 AUSTRALIA AND NEW ZEALAND

### **General Food Safety and Consumer Health Protection**

The Australian and New Zealand legislative instrument of most relevance to the regulation of nanoscale food ingredients, novel foods, nanoscale food additives and contaminants and nanotechnology-derived FCMs<sup>12</sup> is the Australian and New Zealand Food Standards Code (the Food Standards Code).<sup>13</sup> The Food Standards Australia and New Zealand (FSANZ), a trans-Tasman statutory body, administers this code.<sup>14</sup> While the Food Standards Code establishes uniform food standards for foods<sup>15</sup>

sold, prepared or imported into the two countries in relation to, for example, labelling, novel foods, substances added to foods, and contaminants, enforcement and compliance of the standards rests with the Australian state and territory governments and the New Zealand government. The principle objective of the Food Standards Code is to ensure that foods which fall within the regulatory scope of the code which are sold, prepared or imported into Australia or New Zealand are safe. While the code itself does not specifically refer to the use of nanotechnology or the inclusion of nanoscale components in food, its inclusive and wide-ranging nature ensures that nano-foods and FCMs incorporating nanomaterials will fall under its scope. Importantly, pursuant to the Foods Standards Code, foods which are not specifically regulated under its standards may be sold, prepared, or imported into either country without being subject to pre-market authorization approval. The implication of this, as noted by Ludlow (2007: 186), is that 'FSANZ may not be aware that nanomaterials [are] included in the food or other item[s]', which are legally available in the two countries.

In order to strengthen its regulatory oversight over foods that contain nanoscale-derived ingredients or additives, in October 2008 FSANZ released a document outlining several proposed amendments to Part 3 of the Food Application Handbook (FSANZ, 2008). The amendments apply to three main areas of food production requiring to supply information to the regulator on, for example:

- 'the identity and purity of substances in applications for food additives, processing aids, nutritive substances and novel foods is adequate to properly define and assess the chemical entity for which approval is sought'. This would include information pertaining to particle size;
- 'information on the chemical and physical properties of substances in applications for food additives, processing aids, nutritive substances and novel foods is adequate to properly define and assess the application', including particle size; and
- 'information on particle size and morphology in cases where these characteristics may relate to the toxicity of a food contaminant' (FSANZ, 2008: 1).

These amendments arguably suggest that the regulator itself is concerned by the current lack of detailed information pertaining to, for example, nanoscale additives and processing aids, and the need to address knowledge gaps relating to potential toxicity.

As with the EU and US frameworks, the Food Standards Code provides

for a mandatory pre-market approval system for certain foods; within Australia, categories subject to pre-market authorization include novel foods, substances added to foods (including additives, vitamins and minerals, and processing aids), and contaminants (including FCMs). These foods may not be sold or imported legally into Australia or New Zealand without having been subjected to a safety assessment, and authorized for use in food by the FSANZ. Pursuant to the Foods Standards Code, a novel food (as defined by clause 1, standard 1.5.1) may not be sold in Australia or New Zealand until a safety assessment, undertaken in accordance with FSANZ's guidelines, has been carried out on the novel food and the novel food has been expressly listed in standard 1.5.1, along with any conditions of use. The categories of novel foods that may be relevant to nanotechnology include a non-traditional food which requires an assessment 'having regard to – . . . b) the composition or structure of the food; or c) the process by which the food has been prepared' (Clause 1, Standard 1.5.1 Food Standards Code). An important caveat, however, as noted by Ludlow (2007), is that for a food to be considered a novel food it must also give rise to safety concerns. As with the EU's current regulatory framework on novel foods and novel food ingredients (EC 258/97), it would therefore appear that while nano-structured foods could theoretically be considered as novel foods under the code, the nano-structured food would have to be considered 'novel' (on the basis of its composition, structure or by virtue of the process by which it is prepared) *and* the properties of the nano-food would have to be considered to be substantially different to that of its macro-scale counterpart.

### **Regulatory Aspects Relating to Nanoscale Food Ingredients**

Within Australia and New Zealand, substances added to food, including food additives,<sup>16</sup> vitamins and minerals and food processing aids<sup>17</sup> are similarly regulated by Part 1.3 of the Food Standards Code. As with the EU's new system for controlling food additives, food flavourings and food enzymes, the code's standards are based on the principle that only substances that are explicitly authorized by the FSANZ may be added to foods. Pursuant to Part 1.3 of the code, before the FSANZ may authorize, for example, an additive or a vitamin to be added to a food, the substance must be evaluated for safety and expressly incorporated into the code (see Standard 1.3.1 (food additives) and 1.3.2 (vitamins and minerals) Food Standards Code). Authorized substances included in the code's positive lists may also be subject to maximum permitted levels. However, with maximum permitted levels based on the substance's mass, Ludlow has expressed concerns over the appropriateness of this metric as a condition

of use for some substances. In Ludlow's (2007: 193) view, mass is unlikely 'to be an appropriate trigger if that additive is in a nanoform and therefore less material can be included to produce the same or change outcomes'. Moreover, given the nature of the positive list, it would appear that the framework does not differentiate between nanoscale substances added to food and macro-scale substances which have been previously assessed for their safety and have already been explicitly authorized as substances that may be added to food.

### **Regulatory Aspects Relating to FCMs Produced by Nanotechnologies**

Standard 1.4.3 of the Food Standards Code is the primary standard for governing the composition, properties and use of articles and materials that may be in contact with food.<sup>18</sup> The principle underlying this standard is that any article or material – 'including packaging material, which may enclose materials such as moisture absorbers, mould inhibitors, oxygen absorbers, promotional materials, writing or other graphics' (Clause 1, Standard 1.4.3 Food Standards Code) – intended to come into contact directly or indirectly with food must not 'cause bodily harm, distress or discomfort' (Clause 2(b), Standard 1.4.3 Food Standards Code). As with the EU's Regulation (EC) 1935/2004, this standard applies to a wide range of articles and materials that may come in contact with food, with its primary focus on ensuring the safety of these articles and materials. In doing so, the general safety requirement does not deal specifically with substances on their own, or in the articles or materials. This approach, which does not rely on 'positive' or 'negative' lists of additives, is also consistent to that adopted in jurisdictions such as Malaysia (pursuant to the Food Act 1983 and the Food Regulation 1985) and South Korea (pursuant to the Food Sanitation Act). Accordingly, as with EC 1935/2004, the Food Standards Code will only prohibit the use of a substance, regardless of its size, when it can be shown that the substance is 'likely' to cause harm to human health (Ludlow, 2007). Within Australia, this general standard is supplemented by a more detailed standard on plastic materials for food contact use (see the Australian Standard 2070-1999 Plastics materials for food contact use). Unlike the EU, more detailed regulations have not been adopted for other types of articles or materials that may come in contact with food.

## **15.5 DISCUSSION AND CONCLUSIONS**

As highlighted by this chapter, and eloquently stated by Taylor (2008: 55) in respect to the US, 'the regulatory system for food packaging is

extraordinarily complex, legally and scientifically'. This statement would appear to be equally true in relation to the regulatory frameworks for food and FCMs in other jurisdictions including, as observed here, the EU and Australia. The findings of this review reiterate reports by, for example, Chaudhry et al. (2006), Taylor (2006, 2008), Ludlow (2007), Food Standards Agency (2008), Food Safety Authority of Ireland (2008) and the EC (2008a, 2008b) in that the current regulatory frameworks for food and FCMs within jurisdictions such as the EU, the US and Australia, are broad enough to 'catch' foods and FCMs which incorporate nanotechnologies. Despite the fact that current frameworks are not designed to cope explicitly with the new challenges posed by nanotechnologies, the different regulatory layers aimed at controlling the risks in the food chain, and the general safety requirements, which put the burden on the manufacturer and importer to only produce and place on the market food which is safe for consumption, should be effective in safeguarding against the irresponsible application of nanotechnologies. A few uncertainties in regulatory frameworks, however, appear to arise from our current lack of understanding in relation to, for example, a clear definition that encompasses the distinctive properties of nano-ingredients and additives, a clearly defined responsibility/liability for relevant products and applications, appropriate permissible limits that relate to the (potential) effects of nano-substances in food, or an exclusive pre-market approval system. Nevertheless, a case-by-case assessment of the safety of the intended applications by the manufacturers (as recommended by EFSA (2008, 2009)) should guarantee that only safe applications of the new technology access the market. In January 2010, the UK House of Lords' Science and Technology Committee published a detailed report on the findings of their inquiry into nanotechnologies and food.<sup>19</sup> The report was particularly critical of the lack of adequate emphasis on research into potential risks of food products containing nanomaterials, as well as the lack of openness on the part of industry in terms of sharing information on R&D in this area.

While the report recognized that existing legislation, in principle, should ensure that all nanomaterials used in the food sector undergo a safety assessment before they are allowed on to the market 'there are certain "grey areas" where products containing nanomaterials may slip through the regulatory net' (House of Lords, 2010: 6). The recast of key regulatory instruments such as Regulation 258/97 (the Novel Foods Regulation) provide the EU with an opportunity to clarify some of the current ambiguities that exist in relation to, for example, how nanotechnologies and nanosciences are defined, and whether nano-foods would require a pre-market safety evaluation. The proposed recast of the regulation, as with any amendments to other relevant EU regulatory instruments will,

however, need to be negotiated at the EU level, while also taking into account other international frameworks to develop a harmonized strategy for the governance of nanotechnology risks.

Although there is not enough scientific knowledge at present to warrant application of the precautionary principle to nanofood, it seems beneficial for the food industry to develop appropriate initiatives to self-regulate the use of nanotechnologies through best practices and voluntary initiatives (as supported in the House of Lords Report of January 2010). The report suggests that developing best practices will prevent any reckless use of nanotechnologies that might jeopardize its future applications in the food sector, and will also ensure that manufacturers comply with the existing regulations to assure quality and safety of their nano-enabled products. Given the growing interest in the use of nanotechnologies, and the potential for large-scale applications in food products, it would appear beneficial for all parties to take a proactive and transparent approach to ensure safe use of the technology.

## NOTES

1. This chapter is based on an earlier chapter written by the three authors. See: Gergely, A., D.M. Bowman and Q. Chaudhry (2010), 'Small ingredients in a big picture: regulatory perspectives on nanotechnologies in foods and food contact materials', in Qasim Chaudhry, Lawrence Castle and Richard Watkins (eds), *Nanotechnologies in Food*, London: The Royal Society of Chemistry, pp. 150–81. The authors would like to thank Ms Tanja Ehnert, Steptoe & Johnson LLP, for providing outstanding legal assistance.
2. Due to the dynamic nature of the regulatory framework in all of the jurisdictions considered within this chapter, it is important to note that the regulatory review undertaken for the chapter was correct at the time of writing (December 2009).
3. Because, for example, the ingredients already have a history of use at the macro-scale.
4. Due to, for example, a lack of information to the contrary or the lack of a precise definition of the term 'substantially altered'.
5. The principle of mutual recognition allows for the legal importation and sale in a Member State of products that are legally marketed in another Member State even if the products do not comply with the specific regulatory requirements of the country of import, unless authorities of the country of import can demonstrate that the products raise legitimate health or safety concerns. A Regulation confirming the applicability of the principle of mutual recognition to all industrially manufactured or agricultural products, and establishing minimum procedural guarantees for companies marketing their products on the basis of mutual recognition was adopted by the Council of the European Union on 23 June 2008. The Regulation will enter into force 9 months after its publication in the Official Journal of the European Union.
6. For the purposes of this chapter, other relevant legislative instruments include the Dietary Supplement Health and Education Act of 1994, the Food Additive Amendment Act of 1958, and the Code of Federal Regulations.
7. A food is defined under s.201(f) FDC Act to mean: (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article.

8. A dietary supplement is defined under s.201(ff) FDC Act to include: '(1) means a product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: (A) a vitamin; (B) a mineral; (C) an herb or other botanical; (D) an amino acid; (E) a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or (F) a concentrate, metabolite, constituent, extract, or combination of any ingredient described in clause (A), (B), (C), (D), or (E); . . .'
9. The adequacy, or in their view, the inadequacies of the FDA's regulatory framework and nano-foods has also been highlighted by Friends of the Earth Australia. See Miller and Senjen (2008), at pp. 21–4.
10. As noted by Taylor (2008), the three working groups were structured around the following topics: (1) Law, Policy and Process; (2) Science; and (3) Industry Stewardship.
11. For a description of the three case studies, see Taylor (2008: 57–9).
12. For a comprehensive review of Australia's food regulatory framework and its applicability to nanotechnologies, see Ludlow (2007).
13. Available at: <http://www.foodstandards.gov.au/thecode/foodstandardscode.cfm>
14. It is important to note that not all of the food standards that form the Food Standards Code have been uniformly adopted by Australia and New Zealand. For example, New Zealand has adopted their own standards for Maximum Residue Limits and processing requirements for all foods, food hygiene issues and primary production of food.
15. As defined in s.3A of the Food Standards Australia New Zealand Act 1991 (Cth).
16. Standard 1.3.1 defines a food additive as, 'any substance not normally consumed as a food in itself and not normally used as an ingredient of food, but which is intentionally added to a food to achieve one or more of the technological functions specified in Schedule 5. It or its by-products may remain in the food. Food additives are distinguishable from processing aids (see Standard 1.3.3) and vitamins and minerals added to food for nutritional purposes (see Standard 1.3.2)'.  
 17. A food processing aid is defined by Standard 1.3.3, as 'a substance listed in clauses 3 to 18, where – (a) the substance is used in the processing of raw materials, foods or ingredients, to fulfil a technological purpose relating to treatment or processing, but does not perform a technological function in the final food; and (b) the substance is used in the course of manufacture of a food at the lowest level necessary to achieve a function in the processing of that food, irrespective of any maximum permitted level specified'.
18. Metal and non-metal contaminants and natural toxicants are also regulated under Standard 1.4.1. While Standard 1.4.1 does establish a positive list for some contaminants and natural toxicants, the purpose of the list is to set down – where possible – the maximum level for some contaminants and natural toxicants. As with regulatory framework set out in the Code for substances added to foods, the maximum level is set by reference to the substance's mass. However, unlike the positive list established for substances added to foods, the list established under Standard 1.4.1 is not underpinned by the principle that only contaminants or natural toxicants explicitly authorized may be found in foods.
19. House of Lords (2010: 112).

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