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Submission from

Friends of the Earth Australia

To the House of Lords Science and Technology Committee

Nanotechnologies and Food inquiry

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Executive Summary

Friends of the Earth Australia (FoEA) has serious concerns about the use of nanotechnology in agriculture, food and food packaging because:

- Nanoparticles ingested via food or food packaging, to which workers are exposed during product manufacture, and which are released to the environment via waste streams or agricultural use have the potential to cause long term pathological effects or short-term toxicity.
- Decreased particle size may increase the production of free radicals leading to increased toxicity.
- A number of properties apart from size determine the toxicity of a nanoparticle.
- There are serious knowledge gaps in our understanding of the behaviour and toxicity of nanoparticles that present obstacles to designing appropriate new risk assessment.
- *In vitro* and preliminary *in vivo* studies of some nanoparticles used in agriculture, food, food packaging or food contact materials have shown that these materials pose serious new toxicity risks.
- The ecotoxicity of nanoparticles remains poorly understood, however early studies suggest that they may cause serious environmental harm.
- Nanotechnology's widespread use in food and agriculture, resulting in greater consumption of more highly processed foods may have serious social and cultural implications and deleterious impacts on public health that go far beyond the toxicity risks of nanoparticle ingredients.
- Nanotechnology's use in food and agriculture may undermine efforts to support ecologically sustainable, locally controlled, relocalised agriculture and food production that delivers economic, social and environmental benefits to rural communities and that help redress the global food crisis.
- There are ethical, social and cultural reasons that the public may not wish to support nanotechnology's use in food and agriculture. Non-science based concerns about nanofoods must be recognised explicitly by governments as legitimate and the public given the opportunity to reject nanotechnology development in this sensitive area.

The regulation of nanotechnology in food and food packaging warrants a precautionary approach. To address our concerns, we recommend that the following steps are taken:

- Define manufactured nanoparticles and nanoscale food components as all ingredients and additives that are added to food or packaging, including as processing aids, which:
    - measure <0.3 -300nm in one or more dimension, or that have a structure that exists at this scale, or
    - in which particle size is important to achieving the technological function or may relate to a difference in toxicity
- Soluble manufactured nanoparticles and nanoscale food components to be included in nanoparticle definitions, disclosure and safety testing requirements.
- Define as nanoparticles agglomerates and aggregates whose primary particles are nanoscale or which possess nano-structures and subject them to nanoparticle-appropriate risk assessment and exposure metrics.
- Define manufactured nanoparticles and nanoscale food components as a new class of chemicals. Each nanoparticle or nanoscale food component, irrespective of its solubility, must be subject to case by case safety testing that is tailored to the unique risks of nanoparticles, with pharmacological endpoint testing. Testing requirements must be clearly stated rather than being left to the discretion of regulators or the applicant.

- Identify foods to which manufactured nanoparticles or nanoscale food components have been added or which are wrapped in packaging to which manufactured nanoparticles have been added as novel foods and require them to face pharmacological endpoint safety testing. Testing requirements must be clearly specified rather than being left to the discretion of regulators or the applicant.
- Apply a moratorium to the sale of all nanofoods until new nanoparticle risk assessment and detection methodologies are developed and validated, as recommended by the Austrian Ministry of Health.
- Label all nano ingredients, and foods produced using nanotechnology, to give people the capacity to make an informed choice, as well as for public health reasons (to trace adverse effects).
- Apply social and public interest assessment to all applications for use of nanotechnology in agriculture or food production and packaging.
- Assess specifically the potential for nanotechnology to further globalise agriculture and food production and trade and to erode efforts to relocalise food production to address food sovereignty.
- Assess specifically the potential for nanotechnology to promote greater consumption of highly processed foods in preference to minimally processed fruit and vegetables and its implications for public health.
- Recognise explicitly the right of the public to reject nanotechnology's use in food and agriculture
- Develop mechanisms for meaningful involvement of the public in nanotechnology policy and decision making.

Friends of the Earth Australia (FoEA) has serious concerns about the use of nanotechnology in food and food packaging

Ingested nanoparticles have the potential to cause long term pathological effects or short-term toxicity

The potential for nanoparticles ingested via food or food packaging to cause long term pathological effects or short-term toxicity is poorly understood and of grave concern. A small number of clinical studies suggest that nanoparticles and small microparticles that are not metabolised can over time result in granulomas, lesions (areas of damaged cells or tissue), cancer or blood clots[1]. Scientists have also suggested that nanoparticles and particles up to a few hundred nanometres in size in foods may already be associated with rising levels of irritable bowel and Crohn's disease[2]. There have so far been no long-term nanoparticle feeding studies and so the potential for pathological effects remains very poorly understood. Such studies are clearly required to inform the safety assessment necessary before nanoparticles are approved for use in foods.

In vitro *and preliminary* in vivo *studies of some nanoparticles used in food, food packaging or food contact materials have shown that these materials pose serious new toxicity risks.*

As particle size decreases, in many nanoparticles the production of free radicals increases[3], with increasing potential for toxicity. *In vitro* studies have shown that nanoparticles which are now used commercially in food, food packaging or food contact materials, including zinc, zinc oxide, silver, and titanium dioxide, pose serious new toxicity risks[4]. In a test tube experiment 20nm nanoparticles of titanium dioxide caused complete destruction of supercoiled DNA[5]. Also in the absence of UV, in another test tube experiment titanium dioxide produced reactive oxygen species in brain immune cells[6]. Pilot data from test tube experiments show nanoparticle titanium dioxide exposure negatively affected cellular function[7] and caused death of brain immune cells after 24 hours exposure[8]. *In vitro* studies also demonstrate that silver nanoparticles are highly toxic to rat brain cells[9], mouse stem cells[10] and rat liver cells[11]. An *in vitro* study found that for some cultured cells, zinc oxide nanoparticles were more cytotoxic than asbestos[12]. Preliminary feeding studies have demonstrated that high oral doses of nanoparticle zinc oxide and titanium can cause toxicity or changes in physiological function[13].

A number of properties apart from size determine the toxicity of a nanoparticle

Size is a key factor in determining the potential toxicity of a particle. However it is not the only important factor. Other properties of nanoparticles that influence toxicity include: chemical composition, shape, surface structure, surface charge, solubility, aggregation/ agglomeration[14], catalytic properties[15] and the presence or absence of 'functional groups' of other chemicals[16]. The large number of variables influencing toxicity means that it is impossible to generalise about health risks associated with exposure to nanoparticles of a given chemical composition. Each new nanoparticle must be assessed individually and all material properties must be taken into account, including the presence or absence of coatings or functional groups and all physico-chemical characteristics.

The ecotoxicity of nanoparticles remains poorly understood, however early studies suggest that they may cause serious environmental harm

The ecotoxicity of nanoparticles remains poorly understood. However, there is early evidence that nanoparticles of titanium dioxide can cause mortality[17] or behavioural[18] or physiological[19] changes in species such as water fleas, fish or algae that are used as environmental indicator species. Byproducts associated with the manufacture of single-walled carbon nanotubes, mooted for future use in food packaging, caused increased mortality and delayed development of a small estuarine crustacean *Amphiascus tenuiremis*[20]. Earthworms exposed to double-walled carbon nanotubes produced significantly fewer cocoons in a dose-dependent response[21]. If such exposure resulted in reduced numbers of earthworms, this would have a serious negative impact on soil health. Exposure to high levels of nanoscale aluminium has been found to stunt root growth in five commercial crop species[22].

The antimicrobial properties of many nanoparticles now used in food packaging and food contact materials have led to concerns that they may shift into microbial populations and disrupt signalling between nitrogen-fixing bacteria and their plant hosts[23]. Any significant disruption of nitrogen fixing could halt plant growth and have serious negative impacts for the functioning of entire ecosystems. This would have significant ecologic and economic impacts.

To address our concerns, we recommend the following:

Define manufactured nanoparticles and nanoscale food components as those ingredients that are added to food or packaging which:

- ***measure <0.3 -300nm in one or more dimension, or that have a structure that exists at this scale, or***
- ***in which particle size is important to achieving the technological function or may relate to a difference in toxicity***

Particle size can be important to achieving the technological function or result in different toxicity of a food additive, nutritive substance or novel food ingredient. However this alone is not sufficient to ensure that all manufactured nanoparticles and nanoscale food components added to foods and packaging are subject to appropriate new risk assessment. The effect of a nanoparticle ingredient on technological function or toxicity may be unknown to the food manufacturer, even in instances where the nano ingredient does pose novel risks that would be detected were an appropriate risk assessment to be performed. A universal size-based definition of nanoparticles is therefore essential to ensure that all manufactured nanoparticles and nanoscale food components are subject to appropriate risk assessment.

Friends of the Earth Australia recommends defining nanoparticles as ‘particles having one or more dimensions measuring between 0.3nm and 300 nanometres (nm)’. That is, we recommend that 300nm be the particle size at which nanoparticles are considered to be new chemicals and requirements for new health and safety assessments are triggered. This definition of nanoparticles must include soluble particles, and also aggregates and agglomerates composed of nanoscale particles or which have nanostructures. Particles that are larger than this size but that also exhibit novel, nano-specific behaviour should also be permitted to be assessed by regulators as nano-ingredients.

Particles up to a few hundred nm in size share many of the novel biological behaviours of nanoparticles than <100nm in size, including very high reactivity, bioactivity and bioavailability, increased influence of particle surface effects, strong particle surface adhesion and strong ability to bind proteins[24]. As with even smaller particles, particles

<300nm in size have the capacity to be taken up into individual cells[25]. Particles up to a few hundred nm in size may also pose similar health and environment risks to particles <100nm.

Recent studies finding that carbon nanotubes can cause the same disease as asbestos fibres received world wide attention[26]. Yet many of the nanotubes in the studies measured >100nm and so would not be considered to be 'nanoparticles' using a <100nm size-based definition. Poland et al.[27] found that two samples of long, tangled multi-walled carbon nanotubes caused asbestos-like pathogenicity when introduced into the stomachs of mice. One of their two samples had a diameter of 165nm and a length of greater than 10µm. Similarly, Takagi et al.[28] found that in a long term study, more mice died from mesothelioma following exposure to multi-walled carbon nanotubes than died following exposure to crocidolite (blue) asbestos. In this study >40% of sample nanotubes had a diameter >110nm.

Several studies have also reported nanoparticle-like biological behaviour in particles 200nm in size - suggesting strongly that even 200nm is not an appropriate upper limit for defining nanoparticles. In an *in vitro* study Ashwood et al.[29] found that 200nm particles of titanium dioxide adsorb bacterial fragments to their surface and 'smuggle' these into human intestinal tissue where they mimic invasive pathogens and can provoke inflammation. Linse et al.[30] found that in an *in vitro* study, along with smaller nanoparticles, the large surface area and surface charge of 200nm nanoparticles catalysed protein fibrillation (mis-folding). Protein fibrillation is involved in many human diseases, including Alzheimer's, Creutzfeld-Jacob disease, and Type 2 diabetes. Cedervall et al.[31] also found strong interactions between proteins and 200nm particles.

Require disclosure and safety testing for all manufactured nanoparticles and nanoscale food components that are used as food processing aids

We emphasise that given the uncertainties surrounding the physiological and biological behaviour of nanoparticles, including in relation to agglomeration, aggregation, de-agglomeration and de-aggregation processes, risk assessment must be performed on the manufactured nanoparticle or nanoscale food component that is added to the food or packaging, including as a processing aid. This is especially important given the huge deficiencies in existing nanoparticle detection capacity.

Soluble manufactured nanoparticles and nanoscale food components to be included in nanoparticle definitions, disclosure and safety testing requirements

The European Food Safety Authority's "Draft Scientific Opinion of the Scientific Committee on the Potential Risks Arising from Nanoscience and Nanotechnologies on Food and Feed Safety" recognises the significant knowledge gaps regarding the behaviour of nanoparticles, including with respect to solubility. EFSA recognises that even where nanoparticles are of soluble substances, given uncertainty regarding their behaviour, the substance should be treated as a nanoparticle, unless it can be proved that it dissolves with no change to its risk profile. This is particularly important given early results showing that partially soluble substances such as zinc oxide can pose extremely serious cytotoxic risks[32].

Soluble nanoparticles (eg micelles, nano-liposomes and nano-encapsulated active ingredients) must be included within the definition of 'nanoparticles'. Soluble nanoparticles must be subject to new nanotechnology-specific safety assessments and exposure metrics given the large gaps in our understanding of how their potentially far greater bioavailability, solubility and potency will influence their biological and toxicological behaviour[33].

Nano-sizing or nano-encapsulating food additives including vitamins, enzymes or preservatives results in greater bioavailability, improved solubility and increased potency of these substances compared to larger or micro-encapsulated form[34]. These novel nanoparticles are already being exploited commercially. For example AquaNova markets its nanoscale micelles for use in foods and cosmetics *because* they deliver "significantly higher bioavailability" of enclosed active ingredients once ingested or applied to the skin[35]. Omega 3 food additives have in the past been added to food in 140-180,000 nm micro-capsules, for example micro-encapsulated tuna fish oils used by Nu-Mega Driphorm® to fortify Australia's Tip Top bread line (Personal communication with Nu-Mega representative 2007). However to increase the Omega 3 potency and bioavailability, companies such as Aquanova and Zymes are now selling 30-40nm nano-forms or nano micelles of Omega 3 – an incredible 4,000 times smaller than the Nu-Mega range[36].

If nano-nutritional additives and supplements provide an excessive dose of some vitamins or nutrients these may have a toxic effect or interfere with the absorption of other nutrients. Dr Qasim Chaudhry who leads the nanotechnology research team at the United Kingdom's Central Science Laboratory told the Times Online that nanoparticle and nano-encapsulated food ingredients may have unanticipated effects, far greater absorption than intended or altered uptake of other nutrients, but warned that little, if anything, is known currently[37].

Define as nanoparticles agglomerates and aggregates whose primary particles are nanoscale or which possess nano-structures and subject them to nanoparticle-appropriate risk assessment and exposure metrics

If nanoparticles fuse together, they form aggregates which are hard to separate. These nano-structured aggregates may be larger than 100nm – or even larger than 300nm. However in many instances aggregates will have close to the same surface area as the nanoparticles they are made from and will have 'nooks and crannies' on their surface structure that are nano-sized. Where toxicity is driven by surface characteristics, the toxic properties of aggregated nanoparticles may be very similar to that of the primary nanoparticles that compose them. In fact some early studies exposing animals to large nanoparticle aggregates showed effects that appeared to be associated with these primary particles, although the primary particles were more potent in many respects (see reviews in Maynard and Kuempel[38] and Oberdörster et al.[39]). In other instances, nano-structured aggregates may result in greater damage than that associated with the primary nanoparticles. In an inhalation study using mice Shvedova et al.[40] found that aggregates of single walled carbon nanotubes were the focal point of granulomatous inflammation.

Nanoparticles that form clusters but do not adhere so strongly together are called agglomerates. Agglomerates have similar structures and surface properties to aggregates and so may also share the toxicity risks associated with the primary nanoparticles that compose them. Additionally, in principle agglomerates can also change shape or come apart[41]. If particles do not de-agglomerate, their size could reduce their bioavailability relative to that of their primary nanoparticles[42]. However this may not necessarily reduce their toxicity. For example Muller et al.[43] found that 2 months after intratracheal installation of multi-walled carbon nanotubes in rats, pulmonary lesions were caused by the accumulation of large carbon nanotube agglomerates in the airways.

It is still unknown to what extent aggregates and agglomerates will break down into smaller particles in our bodies, eg after ingestion. Researchers routinely use surfactants to 'debundle' single and multi-walled carbon nanotube samples for physicochemical investigation[44]. Biological fluids that contain surfactants or proteins may similarly promote de-agglomeration[45] or even break up of aggregates[46] into smaller particles or even the primary nanoparticles.

The poor understanding we have of disaggregation and de-agglomeration processes and the early evidence that aggregates and agglomerates may share both surface characteristics and toxic properties with the primary nanoparticles that compose them demand that regulators take a precautionary approach and treat these particles as nanoparticles.

Define manufactured nanoparticles and nanoscale food components as a new class of chemicals. Each nanoparticle or nanoscale food component, irrespective of its solubility, must be subject to case by case safety testing that is tailored to the unique risks of nanoparticles, with pharmacological endpoint testing.

The United Kingdom's Royal Society and Royal Academy of Engineering have recommended that given the emerging evidence of serious nanotoxicity risks, nanoparticles should be treated as new chemicals[47] and be subject to new safety assessments prior to their inclusion in consumer products[48]. They further recommended that factories and research laboratories should treat nanoparticles as if they were hazardous[49], and until the environmental impacts of nanoparticles are better known, their release into the environment should be avoided as far as possible[50].

To date food regulators world wide have not treated nanoparticles as new chemicals nor required food and food packaging manufacturers to conduct new safety testing of nano ingredients. The risk assessment process used by regulators for nanoparticle ingredients, additives, nutritive substances, processing aids and contaminants of food or food packaging should be specific to their new risks (eg by requiring full physico-chemical characterisation of particles and nanoscale food components including size, shape, charge, surface properties, solubility, catalytic properties, coatings, presence or absence of functional groups etc). A nanoparticle-appropriate metric must be used for dose (eg particle surface area or number of particles rather than mass). The process used for risk assessment must be explicitly stated rather than left to the discretion of regulators or the applicant.

Identify foods to which manufactured nanoparticles or nanoscale food components have been added or which are wrapped in packaging to which manufactured nanoparticles have been added as novel foods and require them to face pharmacological endpoint safety testing.

The Austrian Health Ministry has called for the European novel food regulations to specifically apply to all foods produced using nanotechnology or nanoscience[51]. Friends of the Earth Australia recommends that the novel foods standard also specifically apply to all foods produced using nanotechnology or to which manufactured nanoparticles or nanoscale food components have been added as ingredients, nutritive additives, processing aids or contaminants, or to foods which have been wrapped in packaging to which manufactured nanoparticles have been added.

In the recently released "Draft Opinion of the Scientific Committee on the Potential Risks Arising from Nanoscience and Nanotechnologies on Food and Feed Safety", the European Food Safety Authority emphasised the serious nature of the knowledge gaps regarding the toxicity of nanoparticles used in food and feed. EFSA suggested that pharmacological endpoints may be needed to ensure that risk assessment of nano ingredients in food and feed did not pose unacceptable health risks:

"The available data on oral exposure to specific ENM [engineered nanoparticles/ manufactured nanoparticles] and any consequent toxicity is extremely limited; the majority of the available information on toxicity of ENM is from *in vitro* studies or *in vivo* studies using other routes of exposure… *There may also be additional toxic effects caused by ENM that are not readily detectable by current standard protocols. Additional endpoints not routinely addressed and pharmacological endpoints may need to be considered in addition to traditional endpoints*" [52] [emphasis added].

The call for nanofoods to be identified as novel foods and subject to a rigorous standard of safety testing using pharmacological endpoints appears eminently sensible. This is especially appropriate given the use of nanotechnology to increasingly blur the lines between foods and nutritional additives ('nutraceuticals') and to promote further use of functional foods that are marketed as having an enhanced health benefit. It is important that packaging is included in this high level of safety testing, given that increasingly nano packaging is being designed to interact with the food it contains. However it should be noted that the Deputy Head of Sector, Safety and Efficacy of Medicines at the European Medicines Agency has suggested that even existing pharmacological endpoints may need strengthening to manage the new risks and challenges of nano-medicines[53]. It is likely that such new standards will also be required for the assessment of nanofood and food packaging ingredients.

Until new nanoparticle risk assessment and detection methodologies are developed and validated, a moratorium should apply to all nanofoods, as recommended by the Austrian Ministry of Health

Given the huge uncertainties surrounding the physiological behaviour and toxicological risks of nanoparticles and the lack of reliable nanoparticle detection methodologies, the Austrian Health Ministry has called for a European-wide moratorium on nanofoods until validated methods for identification and risk assessment have been developed[54].

Friends of the Earth Australia supports this call. As we have said previously, a moratorium on the commercial sale of all nano-products should apply until the safety of nano-products can be demonstrated, all nano-products are clearly labelled, and the public is given the opportunity to be involved in nanotechnology decision making.

All nano ingredients, and foods produced using nanotechnology, should be clearly labelled to give people the right to make an informed choice, as well as for public health reasons (to trace adverse effects)

Manufacturers of products that contain added nanoparticles are not required to acknowledge the presence of nano-ingredients on product labels. This denies consumers the right to make an informed choice about whether or not they wish to eat nanofoods, or foods wrapped in nano-packaging. Failing to label nanofoods precludes tracing any future adverse effects back to their source and also precludes carrying out post-release monitoring.

A recent poll of 1010 Australians carried out by Essential Research and commissioned by Friends of the Earth found that 92% support mandatory labelling of all nano ingredients in foods and food packaging[55]. The poll found that only 15% of people would be prepared to purchase nanofoods, whereas 40% said that they would not purchase nanofoods at all. That is, more than 9 in 10 people want the capacity to choose whether or not to eat nanofoods or food wrapped in nano-packaging, and given the choice, more than twice as many people would not purchase nanofoods. Mandatory labelling of nanoproducts has also been a key recommendation of the United Kingdom's Royal Society[56] and the Austrian Ministry of Health[57].

Foods produced using nanotechnology or nanoscience should also be labelled. Consumers are now looking for labelling not only for ingredients, but also for preparation instruction, storage information, nutrition information panel and processes used in the manufacture of foods. We currently label other foods according to the processes used, for example organic or kosher foods, and this is also important with respect to nanotechnology.

Apply social and public interest assessment to all applications for use of nanotechnology in agriculture or food production and packaging.

Beyond the need for new regulation to manage the serious new toxicity risks associated with nanofood and nano agricultural products, Friends of the Earth Australia is calling for 'fourth hurdle regulation' to require manufacturers to demonstrate the social benefit of products they wish to sell. There is very rarely a requirement for product manufacturers to 'justify' risk exposures in terms of social benefits[58]. Too often, it is an entrenched and unchallenged assumption that the market release of a new functional food or antibacterial product will necessarily deliver public health benefits. In many instances, putative benefits are argued by product proponents to justify or counterbalance the potential for new risks, despite potential benefits rarely being subject to the same kind of scrutiny and scepticism to which claims of potential risks are subject. Friends of the Earth Australia therefore supports the recommendations of Wynne and Felt[59] for the inclusion of a social benefit test, supplementing the more usual investigations into efficacy, safety and environmental risk, as part of the regulation of nanotechnology in food and agriculture.

Assess specifically the potential for nanotechnology to further globalise agriculture and food production and trade and to erode efforts to relocalise food production to address food sovereignty.

Nanotechnology in food and agriculture is emerging at a time when global food systems are under unprecedented stress. Friends of the Earth suggests that by entrenching our dependence on the industrialised, export-oriented agricultural system and the chemical and technology 'treadmills' that underpin it, nanotechnology is likely to exacerbate the problems that caused the current global food crisis.

Recognition by governments, industry and inter-governmental forums of the right of small scale farmers to control food production to meet local food needs, - 'food sovereignty' - has been a key demand from farming and peasant communities[60]. Around 75 percent of the world's hungry people live in rural areas in poor countries. If rural communities can meet more of their own food needs via local production, they will clearly be less vulnerable to global price and supply fluctuations. La Via Campesina's has argued that: "Small-scale family farming is a protection against hunger!" [61].. This view was supported by the four year International Assessment of Agricultural Science and Technology for Development which emphasised that to redress rural poverty and hunger, a key focus of agricultural policy must be empowering small scale farmers to meet their own food needs[62].

The potential role of new technologies in responding to the global food crisis is controversial. As with genetically engineered (GE) crops, proponents have argued that nanotechnology will redress food shortages by promoting greater agricultural productivity. However the recent IAASTD report notes that whereas GE crops have had highly variable yields, they have also had negative broader economic consequences for farmers by concentrating ownership in agricultural resources and introducing new liabilities for farmers[63]. Similarly, Friends of the Earth suggests that nano-agriculture is not required to achieve strong yields, but will add to the capital costs faced by small farmers and increase their reliance on technology, seed and chemicals sold by a small number of global agri-business companies.

By underpinning the next wave of technological transformation of the global agriculture and food industry, nanotechnology appears likely to further expand the market share of major agrochemical and seed companies, food processors and food retailers to the detriment of small operators[64]. Nano-encapsulated pesticides, fertilisers and plant growth treatments designed to release their active ingredients in response to environmental triggers, used in conjunction with nano-enabled remote farm surveillance systems, could enable even larger areas of cropland to be farmed by even fewer people[65]. By dramatically increasing efficiency and uniformity of farming, it appears likely that nano-farming technologies could accelerate expansion of industrial-scale, export oriented agricultural production which employs even fewer workers but relies on increasingly sophisticated technological support systems that have increasing capital costs. Such systems could commodify the knowledge and skills associated with food production gained over thousands of years and embed it into proprietary nanotechnologies. It could also result in the further loss of small scale farmers and further disconnection of rural communities from food production, undermining efforts to achieve sustainable, relocalised food production.

Defending and reinvigorating sustainable small-scale farming requires action by governments to support agriculture that prioritises food production for local populations. This requires land reform, including control over and access to water, seed, credits and appropriate technology. It also requires the removal of trade policies and financial subsidies that preference industrial-scale farming for export or that promote the adoption of technologies or farming practices that will undermine the viability of small-scale farming.

Assess specifically the potential for nanotechnology to promote greater consumption of highly processed foods in preference to minimally processed fruit and vegetables and its implications for public health.

Nanotechnology is likely to influence the eating habits of urban consumers, with associated public health and cultural implications. By enabling manufacturers to promote nano-reconstituted, nano-fortified or nano-packaged foods as delivering superior health benefits, hygiene or convenience, it is likely that nanotechnology will encourage even greater consumption of highly processed foods at the expense of minimally processed fruits and vegetables. Beyond the need to ensure the safety of nanofood additives, it is also useful to question whether or not fortifying food with nano nutrients is actually desirable from a public health perspective. There is a growing number of manufacturers prepared to claim that their nano-fortified beverages or foods will meet a large part, or even the entirety, of an individual's dietary needs. For example Toddler Health's range of fortified chocolate and vanilla 'nutritional drinks', which include 300nm particles of SunActive® iron, is marketed as "an all-natural balanced nutritional drink for children from 13 months to 5 years. One serving of Toddler Health helps little ones meet their daily requirements for vitamins, minerals and protein”[66]. Yet no matter how fortified, nanofoods cannot substitute for the nutritional value of a diet based on a variety of fresh, minimally processed foods. There is a real possibility that the promotion of nano-fortified foods could be one factor in people eating less fruit and vegetables, with associated negative public health outcomes.

By extending the shelf life of ‘fresh’ and processed foods, it is also likely that nanotechnology will further promote the eating of foods out of season and far from the place of their production. In this way, nanotechnology may further erode the relationship that exists (or once existed) between consumers and producers of foods, as well as peoples’ cultural connection to traditional and minimally processed whole foods. The development of a cola drink that could be marketed as having the nutritional properties of milk is a case in point[67]. With the increasing use of nanotechnology to alter the nutritional properties of processed foods, we could soon be left with no capacity to understand the health values of foods, other than their marketing claims.

Recognise explicitly the right of the public to reject nanotechnology’s use in food and agriculture

There is an urgent need for regulatory systems capable of managing the many new risks associated with nanofoods and the use of nanotechnology in agriculture. Alongside managing nanotoxicity risks, governments must also respond to nanotechnology’s broader social, economic, civil liberties and ethical challenges. To ensure democratic control of these new technologies in the important area of food and agriculture, public involvement in nanotechnology decision making is essential.

Mandatory labelling of all nanofoods is required to enable people to make an informed choice about whether or not to eat them. However beyond the need for labelling to enable informed purchasing choices, the public must be given the opportunity to be involved in decision making about the use of nanotechnology in the food and agriculture sector. Given the significant implications of nanotechnology for our relationship with food and agriculture, and for food producing communities worldwide, we call for public involvement in all aspects of decision making, including the right to say no to nanofoods.

Develop mechanisms for meaningful involvement of the public in nanotechnology policy and decision making.

Public awareness about nanotechnology remains very low. However, early surveys show that once given information about nanotechnology, people do not want to eat nanofoods or foods wrapped in packaging that contains manufactured nanomaterials. Public engagement initiatives and experimental studies suggest that once provided with information about nanotechnology, the public is concerned about many of the same issues identified in relation to GE food: a lack of transparency, a lack of choice about exposure, risks to health and the environment, unfair distribution of risks and benefits, a lack of socially useful applications and a lack of public participation in decision making[68]. The significant challenges of a powerful, transformative and controversial technology demand a reciprocal significant government investment in the establishment of new mechanisms for meaningful involvement of the public in nanotechnology policy and development, the allocation of research priorities for public funding and the establishment of governance measures. We commend wholeheartedly the establishment of this consultation process, but it must be recognised explicitly that the public interest issues associated with nanotechnology's use in food and agriculture go far beyond those associated with risk assessment, and a far greater involvement of the public in decision making in this area are required.

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