ETHICS DEBATES ON FOOD TECHNOLOGIES IN THE EU

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TABLE OF CONTENTS

INTRODUCTION

Food is essential for human life and existence. Therefore production of food sufficient to feed the global population in a manner that is sustainable both now and for future generations is essential. For centuries agricultural production was conducted utilising ecologically sustainable agricultural processes. This model still operates in a number of developing countries (in for example, SE Asia, South America and sub-Saharan Africa), but in most of the developed world, there was a move to a productivist model of intensive farming, during the 20th century. The objective of intensified agriculture is increased levels of production, specialisation and expansion through the use of convergent application of biotechnology (including genetics), nanotechnology and information technology. Lowe et al (1993) have defined productivism as "a commitment to an intensive, industrially driven and expansionist agriculture with state support based primarily on output and increased productivity". The consequent environmental damage caused by intensive farming methods has led to the emergence of an alternative, a post-productivist model with the focus shifting from intensive farming to shorter food supply chains, better added value for farmers and more sustainable, environmentally friendly, localised and pluralistic agricultural practices.

Whereas the key stakeholders in the productivist model tend to be farmers, the food industry and policy makers, the stakeholder community of the post-productivist model is much wider and includes in addition to producers, distributers and policy makers, local rural and urban communities, environmentalists, consumers, NGOs, special interest groups and others, with less emphasis on commodity production, and a greater focus on shorter less intense farming, reducing environmental damage, animal welfare and a shift towards sustainable agriculture and conservation or restoration of valued landscapes and habitats (Wilson 2001,80-81; See also Jay, M. (2004)). An important manifestation of this approach has been a change in consumer awareness, behaviour and engagement with the whole of the food chain from “gate to plate” with particular emphasis on perceptions of risk, precaution, “naturalness” and animal welfare, driven to a not inconsiderable extent by a number of high profile health scares particularly across the European market. This has resulted in the development of new market relationships with a consumer driven focus.

At the same time the productivist approach to food production has been moving towards a more agri-industrial model. This industrial model of agriculture depends on further increasing specialisation and homogeneous production, with production control and pricing shifting from primary producers (farmers) to highly competitive industrial distributors and highly industrialised multinational chemical, biological and pharmaceutical companies implementing global value chains. This results in a squeeze on the prices paid to farmers by distributors (van der Ploog 2006) and an increasing pressure for a more intensive production dependent on external inputs of water and energy together with patented, product specific, fertilizer and pesticides and increasingly, the use of scientific research to modify, control and maintain reproduction of crops and animals (Marsden 2008).

In recent years Europe has been the focus of a number of high profile food-related issues or concerns which have had a significant impact on consumer confidence and which have resulted in large changes to the European regulatory structure with important consequences for the development, regulation, economics and politics of the agri-industry. One consequence of these events has been a huge loss of confidence by consumers in the food industry and also in food regulators, and this has been accompanied by strong consumer demand for much greater consultation and input into all stages of the food chain and its regulation. These high levels of consumer sensitivity and much tighter coordinated regulation as a result of loss of consumer trust, has been an important factor in increasing support for the post-productivist model of food and agriculture in Europe. This is in stark

contrast to the situation which exists in the US, where food and agriculture are regulated by the FDA, a body more remote from the US consumer. Much has been written about the confidence and trust of the American consumer in national institutional arrangements and it has proved much easier in such an environment to introduce innovations such as products and processes based on GM technology, which has been much more problematic in Europe (Frewer et al, 2013). As a result the US still remains much closer to the agri-industrial model.

These two agri-food production models now contend in the policy and economic fields for a dominant role in food production and supply to consumers. Both approaches are dependent on continuous scientific innovation in order to develop and maintain competitive advantage. While to some extent the consumer is over a barrel as they are dependent on what is available, i.e. what is provided by producers and distributers, they do have the ability to "vote with their feet" and can and do reject products in which they have little or no confidence. Therefore failure to recognise and respond to consumer preferences and concerns may generate consumer protest and shifting of loyalties to different production systems. Hence the acceptance and trust of the consumer is important for economic viability and it is essential for both models to be able to secure positive attitudes in consumer perceptions of risk and ethical values in relation to methods of production, processing, packaging and distribution. Effective regulation is a key element in securing consumer trust and hence confidence in both products and processes.

We will therefore consider these two agri-food models in relation to innovation, risk and power and control issues together with the associated ethical issues and consumer perceptions.

INNOVATION

The agri-industrial model is dependent on greater control of all stages of the food-chain in order to increase and standardise production and yield and to limit uncertainty and variability in both quality and supply. It might be argued that the focus is an economic one with a view to exploitation of a global market through global value chains. It also seeks to provide technological solutions to food shortages by utilising convergence of technologies to ensure adequate production of food including in developing countries and those where environmental conditions may be unsuitable for many crops and animals. Development of novel food products which may have additional benefits in terms of human health or enhancement is also an important objective.

The post-productivist model has its focus on sustainability, animal welfare, environmental balance, consumer safety, food quality and a more local and regionally based approach to production such as enabling agricultural systems to boost their own fertility. It would be expected to have a more structured and rigorous regulatory system with an expectation of greater consumer engagement at all stages of the food-chain. Nevertheless both models are dependent on effective innovation in order to meet consumer needs and expectations. Therefore the policy behind the funding of the research agenda of the European Union and its constituent Member States is an essential factor in progressing the development of both the agri-industrial and post-productivist models. For a much fuller narrative of how the different models interpret the concept of a Knowledge Based Bio-Economy (KBBE) and so influence the priorities directing the distribution of European research funding see Levidow et al (2012).

This case study however, will focus on potential innovative applications of genetic modification and nanotechnology in the food chain and consider how these innovative technologies have and might be perceived in terms of risk and from ethical and consumer perspectives.

Innovation in Agriculture through Genetic Modification

The EU Directive 2001/18/EC definition of “genetic modification” (“GM”) includes techniques for introduction of recombinant DNA, transfer of heritable material through various artificial ways, and fusion of cells of different organisms that cannot be crossed in nature. These techniques can be applied to both plants and animals. However there are in addition, various other techniques for cloning animals, including embryo splitting and the transfer of a nucleus from a donor cell into an enucleated oocyte. These techniques as well as the cloning through somatic cell nuclear transfer (SCNT), are usually not included in the same category as genetically modified organisms (GMOs) by European regulators, although this is not the case in other regulatory frameworks. (Frewer et al, 2012).

It is clear therefore that “genetic modification” is not a single, homogeneous technology but rather a range of often very different applications having in common the manipulation of genetic material ranging from a single gene transfer to duplication and transfer of the total genetic material contained in a cell. Each one of what may be many different applications, may present very different risks and benefits. Therefore these very different risk/benefit profiles may need to be assessed on a case by case basis (Frewer, et al, 2011).

The agri-industrial model has strongly supported and promoted research on GM technologies that aspire to improve the food chain in a number of important areas.

However, by far the greatest commercial focus has been and still remains on GM to enhance the ability of plants to withstand pests and disease. Monoculture crops in particular are much more susceptible to pests and disease due to the lack of the inherent resistance which exists in a diverse or multi-culture gene pool. Greater use of monocultures as a result of the so-called “Green Revolution” in agriculture led therefore to high intensity farming with an increasing need to use large quantities of artificial chemical herbicides and pesticides (Tilman, 1998). Towards the end of the last century, this large scale use of chemical pesticides and insecticides, gave rise to major concerns about its detrimental environmental impact. Hence the development of GM of plants to provide inherent resistance to both insect pests and disease was considered to be a very attractive proposition [Boulter 1993]. Much work has been done with the insect pathogenic bacterium *Bacillus thuringiensis* (Bt) and Bt genes have been introduced into a wide range of crops. Initially the aim was to genetically modify the plants to enable them to produce chemicals themselves which would destroy the pests, while eliminating the need for using expensive and inefficient pesticides.

However, development of consistently effective genetically modified plants has had very mixed results. Farmer and consumer concerns about the presence of components such as marker genes, that were considered unnecessary and undesirable in potential food crops, together with the difficulties of separating the GM plant from its non-GM equivalent, has resulted in consumer resistance to GM solutions in an increasing number of countries which has led to a number of national and transnational bans [Hilder and Boulter 1999]. As a consequence the use of GM for crop protection has undergone a transition to what might be considered a more socially responsible and consumer aware approach to innovation coupled with a move away from the “chemical” solution to a more focussed pharmacological approach involving the development of GM induced biologically active components that will attack specific biological sites on pests. This might include GM microorganisms designed to interact with and destroy specific pests. GM modification is increasingly seen as one element in a broader multifaceted approach to reducing crop damage caused by pests, which also seeks to be more sustainable and reduce environmental impact is an approach much more acceptable to a post-productivist model. However, according to Slater et al: *“..it is still important to realise that Bt and other GM approaches to insect resistance cannot be viewed as a magic bullet to permanently eliminate the threat of insect damage. Rather the GM crops just alter the balance of all the interactions between plant and environment that occur in the field, and the build-up of resistance in the insect population must be managed by good agricultural practice.”* (Slater, Scott and Fowler, 2008).

Although disease and pest control account for most commercial applications of GM plant technology, there is considerable evidence from research of the potential for GM plants to produce other significant benefits, including the enhanced tolerance to environmental effects such as drought, higher or lower temperatures or flood. This is an area of research that has demonstrated very promising results. Drought, flooding, extreme temperatures, high salinity and the presence of heavy metals in soils are all factors which dramatically affect the yield of food and other crops. A crop grown under ideal environmental conditions might for example produce 10 – 15 times the average yield for that species (Bray et al, 2000). Improved resistance to drought, salinity and extreme temperatures has been observed in transgenic plants that express/overexpress genes regulating osmolytes, specific proteins, antioxidants, ion homeostasis, transcription factors and membrane composition (Zhang et al, 2000). Hence successful commercial development of such transgenic plants could dramatically improve crop yields and also facilitate the growth of crops in hostile environments. There is in addition a growing interest in the development of GM crops (and indeed GM animals) to generate products which have more direct health benefits and also to develop more environmentally sustainable bio-fuels. For more details on current research and potential products from both GM plants and animals, see Annex 1.

Thus the potential opportunities for commercialisation of products from (and including) GM plants and animals are extremely diverse. However their actual implementation has been low, even in those countries where, unlike Europe, GM plants in particular are already widely utilised. This may be due to commercial concerns over consumer reactions to innovative uses of GM or because relatively little commercial benefit has currently been identified. Thus both the large multinationals and the European KBBE research agendas have focussed on those areas that appear to offer more immediate economic benefit However, recent advances in practical application of GM may change this. A significant increase in commercial applications of GM products at the global level could result in Europe being left behind unless it is able to take a strong lead in development of new GM products. This will depend on a number of important factors such as the extent to which GM is seen as a realistic future technology which has significant recognisable benefits for both society and the environment, including real solutions to improving the food supply, particularly in countries where food shortages and unreliable harvests are a critical issue and that GM agriculture is perceived as making a sustainable contribution to global food security.

Although there are a number of persuasive arguments for the implementation of acceptable GM technology into the food chain, including greater sustainability through significant reductions in the use of herbicides and pesticides, increasing yields and broadening of growing seasons and geographical distribution with the real potential to not only feed many more people but, through greater environmental tolerance, to be able to do so locally, reducing both costs and the environmental impact of transportation. The issue of whether alternative technological approaches can be applied to reach the same goals also needs to be considered (Gupta et al, 2012). From the point of view of innovators and commercial interests, the development of GM offers the opportunity of very significant economic benefit and greater control of seed, feed and stock supply. However, there remain, particularly in Europe, very significant consumer concerns and consequent political sensitivity about the introduction of genetic modification into both the food chain and the environment and of disproportionate control by multinational companies to the detriment of small local and national farmers and other producers. One potential alternative to the high technical and economic input approach of direct genetic modification through gene manipulation might be the use of *genomics* rather than GM; i.e. utilisation of genetic testing to provide information to primary producers so that they can identify the presence of genes or markers both for desirable and undesirable traits, so enabling them to make informed, specific and more effective selection of plants and animals from which to produce new generations. As this use of genomics utilises information rather than manipulation it may well be viewed more positively than direct GM by those supporting a post-productivist model.

Despite some signs of increasing recognition of potential benefits that might emerge from GM applications in the food chain, there remain very significant consumer concerns about GM. However, one area of innovation that does not appear to carry the same negative connotations or level of public concern as GM, is the application of nanotechnology in the food chain. Nanotechnology may therefore in some cases be a potential alternative technological approach to the use of genetic modification of plants and animals in the food chain.

Nanotechnology is the manufacture and use of materials and structures at the nanometre scale (a nanometre is one millionth of a millimetre). Nanotechnology covers and is relevant to, a very wide range of food-related applications (Frewer, Fischer et al, 2011). There is therefore no definitive list of foods or food contact products that involve nanotechnology and it is extremely difficult to estimate how widespread is the use of nanotechnology in food and agriculture (Jones, House of Lords Evidence 2009). However there are clear examples of the use of nanotechnology throughout the food chain. Nanotechnology is for example

used in agricultural practices such as improving the efficiency and fertility and micro-management of soils, smart pesticides, and use of nano-sensors for tracking and monitoring of animals and their health and in the development of precision GM. Food processing and manufacture utilises nanomaterials for filtration and anti-clogging processes while they are widely used in food packaging, acting as microbicides, enhancing barrier properties and as microsensors detecting the presence of pathogens or indicating the freshness of foodstuffs. They are being used in food products in order to modify texture and control the way in which individual nutritional components of food are delivered. For a fuller description of current and new developments of nanotechnology in the food chain (see the text adapted from Coles and Frewer (submitted) in Annex 1).

Thus nanotechnology has the potential to become an alternative approach to GM in the development and enhancement of food and agricultural products. Nanotechnology has a considerable advantage over GM in that it has not to date generated the adverse public reaction seen in many societies to genetic modification in the food chain. However one reason for this is that consumers are by and large unaware that nanotechnology already plays a significant role in many aspects of food production processing and supply (See Coles and Frewer (submitted). The possible implications of this are considered in more detail below.

In summary therefore, the actors driving the agri-industrial approach to food production (multinational chemical and pharmaceutical companies, national governments, other European policy-makers, and large scale producers) focus on achieving sustainable systems through high input of energy, agrochemicals, technological innovation and genetic modification with a view to developing a more effective and competitive knowledge-based economies. This in turn has significant influence on the commercial and public research agendas which in turn reinforce the model by funding research which seeks to further those objectives. The actors supporting the post-productivist approach (local farmers, consumers, NGOs, organic producers) favour innovations that promote shorter chains, local producer-consumer relationships, stimulating ecological interactions between of localised biological componants of agricultural systems (Levidow et al, 2012) , lower-cost inputs, with the objective of providing greater economic benefit to primary producers and reducing consumers perceived risk.

In the next section we will focus on the role of risk perception in the failure of GM of food products in Europe.

RISK

All governments have a responsibility to ensure that regulation and other systems are in place to ensure that consumers are protected against foods that may be unsafe. A lynchpin of this responsibility is the well-established process of Risk Analysis. Risk analysis under the *Codex Alimentarius* consists of Risk Assessment, Risk Management and Risk Communication. The risk assessment process is the mechanism for identifying for food products, any physical, chemical or biological agents that may be harmful to health (the hazard), a scientific characterising of the nature of the adverse health effect and the size and likelihood (or probability) of exposure to the hazard. The risk assessment is fundamentally a scientific process. The risk management element relates to the process of determining the policy for handling any risk, and takes account not only of the scientific assessment but also involves taking account of existing regulations and agreements together with consultation with stakeholders. Risk communication was, historically, considered to be the means by which an identified risk and the policy for managing it, was communicated to stakeholders and consumers. However, this approach has changed significantly and risk communication is now considered to be an iterative process that operates throughout the whole of the risk analysis process (Koenig et al, 2010).

As is discussed later in this case study, the normal procedures for assessing risk do not apply to GM agriculture and foods. The risk assessment position adopted for GM foods by US and European assessors is that of “substantial equivalence”. The principle of substantial equivalence comes from an OECD document of 1991 which defines it as follows: “that a novel food should be considered the same as a conventional food if it demonstrates the same characteristics and composition as the conventional food."

The implications of this are that existing organisms or products used as foods or food sources, can serve as a basis for comparison when assessing the safety and nutritional value of a food or food ingredient that has been modified or is new. If a new food or food ingredient is found to be substantially equivalent to an existing food or food ingredient, it can be treated in the same manner with respect to safety and nutritional value, keeping in mind that establishment of substantial equivalence is not a safety or nutritional assessment in itself, but an approach to compare a potential new food with its conventional counterpart (See SCF Opinions on the Assessment of Novel Foods - SCF 1996a,1996b,1996c).

The aim of this approach is to greatly simplify the process of safety testing of a novel food and significantly reduce the timescale for its approval. If a natural equivalent can be identified then the novel or genetically modified food is subject to a number of tests which look for unanticipated changes in the chemicals, nutrients and anti-nutrients, (including toxins and allergens) that exist in the unmodified food. If after testing no such differences are identified then, after an assessment of the genetic modification itself, the new food can be declared “substantially equivalent” to the natural counterpart and no further safety testing is needed.

This simplified and much less costly approach to approval of novel foods encourages manufacturers and industry to embrace the new technology and develop genetically modified and other novel foods and feedstuffs. However several stakeholders, including scientists, scientific and regulatory advisory bodies, NGOs and consumer bodies have continued to express concern about the use of substantial equivalence, arguing that substantial equivalence is only a surrogate for and not a scientific test of safety because amongst other things it cannot identify or predict potential unanticipated changes resulting from the genetic modification itself.

However, although both USA and European regulators utilise the concept of substantial equivalence, there remain significant differences between the two regimes in the way in which GM products are assessed and regulated. The USA regulatory system applies no special regulatory process for the approval of novel foods with approval being based on whether the constituents of the novel food are “substantially similar” to substances found in other foods. This does not require a natural food that is substantially equivalent as even if a gene expressing a particular protein in say, an apple, were to be transferred by genetic modification to express the same protein in a different food, e.g. a cucumber; this would not require approval as the protein constituent is substantially similar. The European approach is however very different, being based on a requirement for novel products containing GM to be labelled as such. The US does not have this requirement. In 1998 a ban on the approval of all GM crops was instituted by 6 EU Member States. This led to major conflict with the US over trading regulations and the US appealed to the World Trade organisation (WTO) on the basis that the EU was operating a trade barrier. In 2003 the EU introduced new labelling regulations on GM foods. The new regulations impose additional labelling requirements so that it is not just the presence of GM material that makes labelling necessary but rather the use of the process of genetic modification in the production of the food. As a result products *derived* from GM materials have to be labelled. For example, oil derived from GM rape, would have to be labelled as such even though the oil itself may contain no trace of GM material. Animal feed derived from a GM source also has to be approved. Until 2008, no live genetically-modified organisms had been approved for food use in the EU. The only foods currently (2013) approved for use in the EU are those containing or produced from GM soya bean or GM maize.

Such approvals as there are have been based on the principle of substantial equivalence. A key to the significant difference in the EU and US approaches to food safety lies in the EU adoption of the Precautionary Principle (PP). The PP was adopted in Europe in 2000, partly in response to the public backlash against the introduction of GM products (both food and crops). Prior to a push-technology initiative by Monsanto (with the strong support of a number of the governments of EU Member States) to introduce GM products into the European market, GM food was already being sold in the form tomato paste produced by Zeneca. From 1996 this product was displayed on supermarket shelves clearly labelled as produced from GM tomatoes and was also less expensive than conventional tomato paste. Sales rapidly increased and overtook sales of conventional tomato paste produced from unmodified tomatoes. However, in 1998 sales of the GM product rapidly declined.

The reason for this sharp decline was a transformational change in public attitudes to the introduction of GM. There has been much analysis of the reasons for this change of public attitude but much of it is unquestionably related to a sharp decline in public confidence and trust in relation not only to industry, particularly multinational companies, but also to regulators and even to government itself. A key factor in this shift has been changes in public perceptions of food-related risk. Increasingly negative perceptions of food-related risks had been developing throughout the 1990s in Europe as a result of a number of very high profile food scares such as Salmonella, BSE and a foot and mouth disease epidemic, which not only had negative impacts on consumer confidence in food safety and the food supply chain, but also those institutions responsible for governance associated with consumer and environmental protection. There is considerable evidence that media reporting made a significant contribution to this “social amplification of risk” or increase in risk perception (Frewer et al 2002; Burns et al 2003). One effect of the media coverage was to highlight industry practices in agriculture (such as incorporating rendered beef products into cattle feed) which consumers considered at least distasteful and in many cases unethical and immoral. This made consumers suspicious of both industry and regulators (Frewer and Salter 2003). Another significant contributory event was a televised claim by Dr. Arpad Pusztai, a researcher for the BBSRC’s Rowett Research Institute about

detrimental health effects in laboratory rats fed a diet of a toxin found in genetically modified potatoes. Dr Pusztai was immediately removed from his position at the Institute and subsequent analysis of his data has failed to corroborate his statement. However the scale of the reaction of much of the scientific, political and industrial communities to his claim was perceived by many to be disproportionate to what would be the usual expected response to a scientist whose claim was questioned. It is here that context is important. Dr Pusztai's announcement took place at a time when European governments and the UK government in particular, were strongly supporting Monsanto's introduction of GM products into Europe. In addition many European governmental research institutes were investing heavily in GM technology as part of the KBBE to be developed as a result of the EU Lisbon Agenda 2000 *" to make the EU "the most competitive and dynamic knowledge-driven economy by 2010"*. It would appear from the scale of the institutional reaction, that Dr Pusztai's claim was seen as a huge threat to these developments and their associated scientific and economic interests. Unfortunately for those with strong interests in promoting GM technology, partly because of the public nature of Dr Pusztai's claim, the whole drama was played out in a public arena which was already experiencing a decline in public trust and confidence in industry, government and regulators, particularly in the agrifood sector. Therefore the Pusztai claim and the institutional reaction to it acted to confirm the public's worst fears and added to the general mistrust of GM technology and those with scientific and institutional responsibility for developing and regulating it.

Another important element of the public concern about GM products was that, unlike the Zeneca tomato paste which was being sold as a novel food at a reduced cost and had potentially better flavour than the traditional paste and was therefore providing clear benefit to the consumer, the GM products which Monsanto sought to introduce into Europe had no identifiable benefit to the consumer but were perceived as having an economic benefit primarily to Monsanto itself and, to a lesser extent, to farmers and other producers. However because of the absence of an effective risk assessment of GM products that commanded public confidence, the perception was that the benefits differentially accrued to the manufacturers and the producers while all the risks, whether real or potential, would be borne by consumers, the environment and possibly future generations. A further aggravating factor was that, while the Zeneca tomato paste was clearly labelled as being a GM product, Monsanto and some regulators adopted the approach of US regulators: i.e. that because the GM products were "substantially equivalent" to their natural counterparts there was no need for foods produced from them to be labelled as indicating that they contained GM ingredients or that GM was involved in their production. The consumer interpreted this approach as a violation of their right to choose whether or not to consume GM products which, in a climate of growing mistrust, only confirmed their fears about GM. As a result there was an almost total public rejection of the introduction of GM products into Europe coupled with demands for a risk analysis process and regulatory regime that took adequate account of the interests and perceptions of all stakeholders (Konig et al, 2010). This mistrust of both regulators and multinational innovators and producers contributed to increased consumer support for more post-productivist models of agriculture and food production, incorporating more "natural" and "environmentally friendly" low input sustainability approaches with greater reference to the fundamental ethical principles of benevolence, non-malfeasance, autonomy and justice.

Thus the risk analysis paradigm was driven (initially very reluctantly) to incorporate much more overt reference to these fundamental ethical principles. This increased recognition of an ethical dimension to the process of risk analysis has been an important factor in the development of risk communication, including consumer consultation, as an important iterative process throughout risk analysis. Together with parallel concerns about the possible impact of GM and other novel technologies on sustainability (another ethical issue), it has also been important in the development of the Precautionary Principle. These changes will be further discussed from an ethical perspective below.

POWER & CONTROL

We have defined the Power & Control discourse as the mode in which S&T developments may affect, on a national or global scale, existing social, economic or geopolitical power relationships. This involves debates on risk and safety of technological developments and their implications in legislation. More often than not, existing laws are inadequate in covering qualitative changes in S&T developments and the ensuing debates involve a range of basic values systems that form the background of the main arguments. In analysing the Power & Control discourse we need to provide interpretations in view of the main interests in the debates, their representatives, the quality of the outcome (i.e. the ensuing legislation) and the remaining challenges. In this section we will attempt to do this in relation to the discourse on Genetically Modified (GM) foods in Europe.

One could rightly argue that the GM food debate in Europe is the most intense and longest-held public debate on this technology in the world. Its ramifications spread from rural/regional to international disputes and from individual conflicts to national posturing. The debate started in the early 90s, with the introduction of the first GM food product in the European market (GM soya) and even after twenty years it shows little signs of an ultimate resolution. In this section we will give a short overview of the main arguments in this discourse and their relation to core values that guide them, as well as describe the main legislation covering the area and discuss remaining challenges.

Both proponents and opponents of GM crop and food technologies have a relative stable argumentation in the last two decades. Proponents highlight benefits in terms of higher productivity, environmental protection (decreased use of pesticides and fertilizers) and health (more nutritious and healthy food). Opponents of the other hand highlight risks in terms of environment (decreased biodiversity and sustainability) and health (unspecified long-term effects and allergies). Some arguments relate also to global perspectives with proponents viewing the technology as a possible solution to food security (through higher yields and climate-proof crops) and opponents viewing it as a hindrance to food security (through loss of biodiversity and monopoly rights in new varieties).

The activities of Civil Society Organisations (CSOs), by and large strong opponents of the technology, have been intense and successful in reaching the general public. Public perception research has shown a relative constancy in the past decades against GM foods and crops in the majority of EU member states. This has produced uneasiness in policy debates and deadlocks in legislative processes as policy makers have found it impossible to reconcile standard risk assessment procedures with the public outcry against GM technologies. The result of the policy debate impasse has resulted in two initiatives that are unique in the European context and have had great repercussions on the Power & Control discourses in Europe and beyond (Trichopoulou, 2000): the first was to agree in 1998 on a policy moratorium for approvals of GMOs in Europe, an action that was based not on scientific proofs of environmental or health risks but on the lack of risk assessment to deal with qualitative rather than quantitative changes (the so called “substantial equivalence model”) and the inability of authorities to reconcile scientific and public opinions. The second, and far more momentous initiative was to adopt in 2000 the Precautionary Principle (PP) in the EU’s legislative processes. According to PP, lack of scientific consensus is adequate reason in prohibiting approval of new food products, even if traditional risk assessment procedures fail to uncover specific risks to health and the environment. The application of the PP in GM technologies has been immediate and widespread.

The consequence of this debate is that the Power & Control discourse in Europe has taken a turn into a controversial but pragmatic separation in decision making: that between science and politics (Sauter, 2005). Scientific decision making relates to risk assessment and also risk management. The creation of the European Food Safety Authority (EFSA) has been the result of the attempt to mainstream scientific decision making in Europe, amongst others, on the risks of GM foods to human health and the environment. EFSA's responsibilities lie in risk assessment while risk management is dealt with by the European Commission's Directorate General for Health and Consumers. Political decision making on the other hand deals with approval of GM foods and can apply the PP to limit authorisation of new products and request post-market monitoring of environmental and health effects, even in the absence of strong scientific evidence to corroborate such requests.

This separation in responsibilities is problematic in itself, more so since scientific debates are inconclusive in relation to actual practices. For instance, there is disagreement amongst experts over the feasibility of co-existence between GM and non-GM crops and also the feasibility of labelling provisions under the actual growing practices in the field (INRA, 1999). Such disagreements are intertwined with the more emotional aspects of the public discourse (e.g. unnaturalness, playing God, etc.) and eventually produce deadlocks in the policy debate. This is most evident at the European Commission level of decisions making, whereby the preferred policy process that is based on Committees with membership representing member states (and therefore reflecting the various public and policy discourses in Europe) is deeply dysfunctional and in a stalemate situation (Vazquez-Salat et al, 2010).

In terms of specific legislation guiding the area of GM foods, the European Union functions through a centralised procedure whereby an agreement between member states results in binding legislation that requires compliance by States (von Schomberg, 1998). Legislation relating to genetically modified organisms (whether food, feed, crops or microorganisms) is relevant to GM foods. It involves a wide range of legal documents, the most important of which are (Vazquez-Salat, et al, 2010; Salter et al, in press):

- Directive 2009/41/EC on the contained use of genetically modified micro-organisms. It regulates the use of GM microorganisms that includes initial research on plants.

- Regulation (EC) 1829/2003 on genetically modified food and feed. It regulates risk assessment procedures, describes the function of the European Food Safety Authority and allows for a single approval of GM plants for food and feed purposes.

- Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms. It regulates risk assessment in relation to the environment, includes socio-economic assessment and provides a platform for ethical considerations.

- Regulation (EC) 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC. It enforces labelling of products and traceability of producers and companies involved, through a post-market monitoring system.

- Regulation (EC) 1946/2003 on transboundary movements of genetically modified organisms. It is based on and enforces the Cartagena Protocol on Biosafety in relation to GMOs and allows for
- penalties in cases of non-compliance.

One can deduce that the central value that permeates the GM food legislation is Europe is that of “Freedoms” in particular Freedom of Choice. In the absence of scientific arguments for an outright ban on GM products, legislators have accepted the immense pressure from CSOs and the widespread opinion of European citizens that “informed choice” is necessary in this issue, hence, enforced labelling and traceability. It should be noted that labelling is widely used in food products but only in relation to warning on allergens in the content or for religious prerogatives (e.g. Halal food). As such, the central value of “freedom of choice” has found a new use that brings it in direct opposition to commercial market forces while recalling the traditional discourse over fundamental rights.

Similarly, another basic value has been used in the Power & Control discourse and is reflected in the current legislation is that of “sustainability”. Although not a traditional value that is imbedded in Charters of Rights, Sustainability has been upgraded to a fundamental value linked to almost all S&T related discourses. In relation to GM crops/foods, Sustainability refers to the loss of biodiversity but also to the loss of traditional agricultural methods. In both cases, GM foods are considered unsustainable and therefore risky and unethical choices.

Both values of Freedom of Choice and Sustainability have controversial implications for policy initiatives. For instance, the policy framework makes traceability and labelling of food derived directly from GMOs, imperative. This is not the case for products from animals fed with GM material and not for industrial products like textiles or paper. Labelling is imperative when the GMO content exceeds 1% of the product. This by itself necessitates the use of sensitive biosensor equipment and a robust paper-trail of content origins, in both cases raising the cost of the product. But even more controversial is the so-called Zero Tolerance Policy for GMOs that are not (yet) approved in the EU, but are on the market in other countries. No amount of traces of such GM material in food products is allowed thus creating an even more restrictive regime on traceability.
The status of the legislative debate in Europe is very advanced compared with the rest of the world but there are still a number of open issues that prove significant barriers to a common resolution. For instance there are no common rules for the organisation of co-existence between GM and non-GM crops in agricultural practice. This issue, along with the relevant issue of liability (i.e. contamination of a non-GM crop by a GM crop), is not decided at EU level but by each single member state. This creates potential confusion since states could have different and even contradictory legislation with each other. At the same time, there are often contradictory votes within the European Union by different states that shows a far from common EU view of the issue and even more worryingly, there are often different positions between Commission Directorates (e.g. health, consumer interests, trade, environment, agriculture etc.) (EPTA, 2009). This creates an even more damaging situation whereby policy debates take a radically different turn according to the values held by different departments.

Overall one might conclude that the implicit split of responsibility between science (i.e. safety assessment) and politics (i.e. decision making on approval) is far from clear. More often than not, this leads to contradictory perspectives and representations and eventually to policy deadlocks. This situation could even get more complex if the current request by some member states to include socio-economic aspect in the risk assessment is accepted (Vazquez-Salat et al, 2010). This could create a more politicized scientific assessment process with great repercussions in the overall decision making.

One could conclude that there are considerable challenges in the Power & Control debate in Europe that relate to core values held by the main stakeholders and the European public in general. The main policy reports in the GM foods debate (e.g. EPTA, 2009) have identified certain challenges that GEST can relate to current value systems:

It is evident that the overall technological and trade conditions in the world, as well as in Europe, encourage the introduction of GM technology in food although also GM crops for non-food uses (e.g. for bioenergy) will be more available. This brings into the forefront of debates the value of sustainability in agriculture. Europe will be increasingly faced with a choice of how to apply sustainability in the sector and what type of agriculture to adopt. The two types of agriculture that we identified in the introduction (agri-industrial and post-productivist) represent diametrically different values systems and this will be the main battleground in this issue.

The new generation of GM applications targets, in addition to growers and producers, consumers directly. New crop varieties are designed to provide direct health benefits to consumers (e.g. via nutritional enhancement) that blur the border between pharmaceutical and food applications. Public reactions to such applications are not easily predictable since health biotechnologies tend to provoke less negative attitudes. Ethical concerns are also not easy to foreseen since a new utilitarian perspective could result in radically different outcome in this case. Policies on consumer protection will need to be relevant in a different type of risk discourse that is more relevant to values related to health research, such as dignity and rights, rather than the current one based on sustainability.

Furthermore, one should not discount the repercussion of the global debate on GM crops and foods that takes place at international policy stages such as the World Trade Organisation (WTO) and the Organisation for Economic Co-operation and Development (OECD). Different approaches to policy signify different assessments, perceptions and ultimately different core values in different countries. As the global debate is developing and crystallised in inherently incompatible approaches to this issue, the identification of the values systems that guide the arguments will be significant in attempting any resolution.

Finally, it is clear that in the Power & Control debate in Europe, public opinion is a decisive factor and the single most important influence in the final decision making. This aspect will be discussed in later sections but here it should be noted that the future direction of public opinion's influence in the debate is far from clear. At present, there appears to be less public opposition to GM food than ten or twenty years ago and even a positive attitude for GM technologies when applied to health. Lay morality is a pivotal influence but also an uncertain one since not the values themselves but the weighting applied to each of them might change with time. The greatest challenge in the Power & Control debate in Europe is to manage its complexity, secure a comprehensive information flow and discuss values and arguments at a similar level.

REFLECTIVE ETHICS AND LAY MORALITY

We have already seen how public perceptions of fairness in the differential distribution of risk in relation to the introduction of GM products into the human food chain have resulted in consumers' in Europe being unwilling to accept the introduction of GM products that ignore the fundamental ethical principles of autonomy, beneficence, non-malfeasance, justice and autonomy. Here we will consider these four principles in more detail in relation to the way in which they are both perceived by and affect different stakeholders in technological innovation in the food chain. The stakeholders we will consider are innovators, farmers (primary producers), food manufacturers and distributers (secondary producers), consumers and the environment.

Innovators

We will take as an example of an innovator, the company Monsanto. The reason for selecting Monsanto is their prominence in the late 1990's in leading the push-technology initiative to try to secure a European market in GM food products, described earlier in this report. Monsanto has continued to develop a number of GM products including a range of GM crop species which are "Roundup ready", being resistant to the herbicide glyphosphate ("Roundup") – allowing continuing sales of the Monsanto proprietary herbicide "Roundup". This increases crop yield by enabling individual plants to be planted closer together, but at the same time encourages increased use of the herbicide; they have also developed the synthetic hormone rGBH (recombinant bovine growth hormone) which increases milk yield in cattle; as well as GM plants that produce the Bt insecticide toxin. They are currently developing drought-resistant GM crops. Some years ago it was claimed that Monsanto had also developed genetic use restriction technology (GURT or "terminator technology") seeds which would prevent farmers from sowing seed harvested from a crop to produce a second crop but would instead have to purchase fresh seeds from the manufacturer. In 1999 Monsanto gave a commitment that they would not develop or market "terminator technology". While Monsanto have maintained this commitment, contracts from Monsanto and other patent-holders for the supply of seeds do however frequently include a condition of purchase that the farmer will not harvest seeds for reuse.

All innovators, from small start-up technology SMEs to multinational corporations such as Zeneca and Monsanto, have an interest in pushing forward the frontiers of science and developing new and innovative solutions to address the challenges of global food security. However, because in most cases they operate in the competitive environment of the market economy, and have a responsibility to their shareholders, their primary objective and hence perspective of beneficence, is not only to be financially viable, but for any innovation to be as profitable as possible and for it to be fully protected from competitive exploitation. Secondary to this is their social responsibility role of seeking to have a positive impact on global food security. Their primary view of *none—malfeasance* would be that the innovation does not damage either the company's profitability or its reputation, and that any products derived from it would have no adverse effects in the market. The innovators perspective on *justice* would require that regulation should not prevent the exploitation of their innovation and that they and their product should be protected against trade barriers and unfair competition. Their view of *autonomy* would be that it is their right to choose how they should develop, exploit and market their innovation.

Farmers

In terms of *beneficence*, farmers are concerned about increasing the yield of a crop or stock so as to maximise their profits and make a healthy living. At the same time they are looking for crops or stock that will simplify their task, reduce both time and effort and minimise risk of loss. They will also be interested in maintaining consistency in their produce in order to build confidence and repeat orders in their customer base. In the case of *non-malfeasance* they should avoid crops, stock or any other supplies or processes which might increase health and other risks to themselves, their business or their customers. They would wish to avoid anything which has the potential to damage the environment or adversely affect animal welfare. They would look for justice in being able to establish an equitable deal between themselves, their suppliers and their customers and to be subject to regulations that enable them to trade freely on a level playing field. Farmers would want as far as possible, to be *autonomous* in their ability to choose which crops and stock to farm, together with the ability to change their chosen product or their supplier if circumstances change.

Producers

The *beneficence* interest of producers is also in reducing costs, maximising profits and expanding their business through innovative technology, the quality and attractiveness of their products, effective marketing and maintaining their reputation. *Non-malfeasance* involves ensuring that their products contain no contaminants harmful or otherwise; that any allergenic or otherwise potentially harmful products are clearly labelled and that marketing and advertising is not misleading. In the case of justice, they would wish to be able to trade freely, to not be subject to unreasonable or overly burdensome regulation particularly in relation to production, marketing and labelling. Producers would desire autonomy in choosing their suppliers, production methods, marketing and labelling strategies.

Consumers

The consumer occupies a significantly different position to that of innovators, farmers or producers and distributers in that the others all have economic benefit as their primary goal. However the primary interests of consumers are their personal health and well-being and the extent to which a particular food product meets their needs including needs relating to food quality and sensory characteristics. Therefore the way in which they apply the four ethical principles is somewhat different. Consumers relate the concept of beneficence to a whole range of actual or perceived benefits that they may get from a particular food product. These might include affordability, flavour, convenience, health benefits, contribution to social interaction, availability of supply and assurance that the food is safe. *Non-malfeasance* on their part may include avoiding doing harm to themselves or others close to them through their food choices, not promoting unfair competition or providing support for local, national or fair trade producers (although there may be some conflict between these aims). There is for the consumer considerable overlap between the principles of justice and autonomy. The consumer wishes to have the right to make free and informed food choices. In order to be able to do this they need to be treated fairly by being provided with accurate information that is sufficient for them to be able to make an informed choice. In most cases this information would normally come through advertising or labelling. It may however also come from information provided by regulatory or government bodies, or indeed the media. Advertising by producers must therefore be fair in that it does not make any unjustified or unrealistic health claims or other spurious benefits. Labelling must provide the consumer with information on any potential hazards including information on possible allergenic substances or toxins. However in addition to labelling of ingredients

that may cause harms or health benefits, the consumer may require additional labelling to facilitate informed choice. This might include information on PDO (Protected Designation of origin), PGI (Protected Geographical Indication), the *appellation* system or "Fair Trade" designations. One particular area which has an almost global consumer demand for labelling is that of GM (Frewer et al 2013). This includes not only food products that contain genetically modified components but also products which have been produced through processes involving GM. This can put the consumer position at odds with the policies of regulators and industry. The consumers' position may be driven by an on-going perception of there being unknown risks associated with GM, even though there is evidence that the consumer position relating to GM is becoming less negative as potential benefits are being increasingly recognised (Frewer et al 2013) and clear evidence of harm from GM products has not emerged. This gives consumers more opportunity to be able to make a risk/benefit decision. However, the on-going demand for labelling indicated that in addition to perceived risks, the principle of autonomy is also important to consumers.

Environment

The fundamental ethical principles can also be applied to the environment. However beneficence, none-malfeasance, justice and autonomy are much more closely intertwined in considering whether GM or other new technologies are likely to have some impact on the environment. Impacts might be through consumption of environmental resources, unintended contamination as a by-product of production or use or contamination by waste materials that are none-recyclable or sustainable. The "balance of nature" dynamic associated with environmental impacts requires careful consideration of potential unintended consequences associated with even apparently beneficial application of innovative technologies. For example, the use of carbon nanotubes to clean up agricultural land polluted with heavy metals might be considered a beneficial application. However if the subsequent fate or impact of the nanomaterials is unknown then it may be more appropriate to adopt a precautionary approach.

In terms of application of ethical principles to the development of new technologies, the roles of innovators, farmers and producers are relatively straightforward to understand as they operate to a greater or lesser extent under market principles which are fairly well-defined and understood. However the position of the consumer, and indeed the environment is, as we have already seen, much more complex and may require consideration of a whole range of preferences, values and cultural mores, many of which may be conflict with one another. In addition consumer responses are frequently moulded by perceptions which may or may not be accurate or have any factual substance. The environment not being an autonomous entity requires "champions" to identify, oversee and protect its interests. This role is to a large extent taken up by local communities, NGOs and other pressure groups putting considerable political pressure on national governments and international bodies and framing the issue of the environment in terms of ethics and sustainability.

Values

There is a greater reluctance to accept GM animals and any food products derived from them compared to GM plants which seems to arise from risk perceptions, social concerns and ethical values (see Annex 1). These heightened concerns about GM animals which includes concerns about animal welfare and use of GM animal feed, appears strongest in Europe although consumers in SE Asia and the US have greater ethical concerns than those in Europe. However regardless of location the great majority of consumers believe that all GM food products should be clearly labelled.

Thus consumers bring into play a wide range of values and concerns which have to be balanced and weighed in determining their response to the introduction of innovative technologies in the food chain. This might include considerations about perceived risks to health, the environment, specific individuals or groups in society. Identification of benefits is also important, as is the concept of fairness. It is therefore essential that innovators, manufacturers and suppliers recognise this and consider carefully the approach used to introduce a new technology. Identification of direct benefit to the individual consumer makes an innovation much easier to introduce and be accepted by consumers. Consumers will often also accept innovations with a clear societal or environmental benefit even if they themselves do not benefit as individuals. However, consumers might well reject a technology simply because they perceive that it is being introduced in a way that is unfair or exploitative or they believe that it limits or removes their freedom of choice. The influence of the media on consumer perceptions should not be ignored. It is entirely possible that a vigorous media campaign that heightens concerns about a new innovation could on the one hand result in a consumer rejection of an innovation which they feel is risky, or they have no interest or benefit. On the other hand it could result in a rejection unsubstantiated by fact and which is unfair to the innovator. Strong media support for an innovation could of course also result in consumers becoming much more accepting.

Therefore the way in which a food-based innovation is introduced into the market is critical to the way in which it may be perceived and accepted or rejected by consumers. Innovators have clearly learned some lessons from the GM foods situation particularly in Europe it has become clear that a push-technology approach will not work without there being clear and easily identified benefit to consumers. Central to this is the application of effective risk communication as an iterative element in the risk analysis process. By effective engagement with the consumer and other interest groups through a risk communication paradigm, a better assessment and understanding of risks both actual and perceived, can be incorporated into the risk analysis process and this in turn can give rise to adjustments both to the overall assessment of the risk, and to additional on-going communication with the consumer. This in turn leads to better management of real and perceived risks and to the introduction of new products into the market. The Food Standards Agency (FSA) established in the UK after the BSE crisis was given the responsibility for risk analysis of food in the UK and designed to have effective risk communication as a core component. Unfortunately the European Food Safety Agency set up shortly afterwards did not adopt this model. Instead, EFSA simply carries out scientific risk assessments and communicates the results of its risk assessment to risk managers and policymakers and does not see a risk communication interaction with European citizens as part of its role. Policymakers likewise operating at a bureaucratic and regulatory level also do not see public risk communication as part of their function. Instead the risk communication aspects appear to be seen as a subsidiarity issue to be dealt with at the national level. As a result the integration of risk communication into the overall risk analysis process has been lost in the European context. This could turn out to be found to be a serious miscalculation if another major food crisis emerges in Europe or elsewhere.

This leads to the question of whether the approach currently adopted by innovators in fields other than GM is the correct one. The introduction of nanomaterials into the food chain is a case in point. As described in this report (see Annex 1), there are a large number of nanotechnology-based innovations already operational in the food chain. At the same time there is neither a clear European legislative structure nor any consistent risk assessment procedure to deal with food-related nanotechnology innovations. In addition, there are no requirements for labelling of nanotechnology-based foods, processes or agricultural practices. Thus there seems to be something of a “free for all” in the use of nanotechnology in the food chain with consumers and indeed some producers such as farmers, having little or no information about the extent to which nanotechnology is incorporated into the food

chain. This may well be one of the main reasons why there are currently few consumer concerns about the implementation of nanotechnology innovations. However even if applications of nanotechnology may be able to bring significant benefits to different levels of the food chain, any claims of potential benefits of themselves cannot justify the use of these nanotechnology applications without some understanding of the magnitude and likelihood of any potential risks. Risk/benefit balance is an important ethical consideration. Manufacturers, processors and producers have a responsibility to ensure that there is minimal risk to end-users including consumers, animals, the environment as well as to future generations. While some degree of risk or potential for harm may however be acceptable if there is an even greater potential for the application to be of benefit (beneficence – to 'do good'), there must be complete transparency and risk communication about both potential risks and benefits to consumers so that a free and informed choice is possible.

The ethical principle of Justice (fairness) requires that where there does exist a potential for risk, there should be fairness in the way in which, and by whom, these risks are borne. First of all, fairness requires that those exposed to such risks should be aware of them. Also where there is a benefit arising from the application then it should be clear to whom any such benefit would accrue. Application of the principle of fairness also means that those who are subject to the greatest risk should also have the potential to receive the greatest benefit [See Coles and Frewer, submitted].
Consumers should therefore be in a position to exercise the right to choose whether or not they wish to be exposed to unknown potential risks. Effective autonomy depends on the ability of a rational individual to make an informed, uncoerced decision. In order to do so they first need to be provided with the necessary information. This means having the means to assess the risks and benefits (whether real, perceived or unknown) associated with the application of the technology used to create the food. Also in order for a decision to be uncoerced the individual needs to be aware that there is actually a choice to be made. At present it would appear that many developers of nanotechnology applications in food are utilising processes and bringing products to the market without making the consumer aware that nanotechnological processes or substances are involved. Indeed it would even seem that those responsible for regulating elements of the food chain in the European Union are reluctant to consider whether the precautionary principle might be appropriate for food-related nanotech innovations.

It may seem to be not in the interests of producers or distributers to highlight the presence of nano-materials in case consumers choose not to purchase the product. However following a number of major food crises resulting from consumers perceiving they had not been fully informed on food chain processes, particularly in the cases of BSE and genetically modified foods, most manufacturers now recognise the importance of an open and ethical approach to informing the consumer and providing them with sufficient information to enable them to make an informed choice. Central to informing the consumer is the principle of adequate and appropriate labelling to enable consumers to identify both ingredients and processes related to the production of their food. Food labelling is a key instrument in facilitating consumer autonomy. It enables the consumer to choose what food and food ingredients they wish to eat. Labelling is important for all food products but with both modern food processing and more particularly innovative technologies there is a particular need for the consumer to be fully informed on both ingredients and processes. This is especially relevant where consumers may have ethical, safety or sustainability concerns about foods created by particular technologies and or processes. [Coles & Frewer, submitted).

CONCLUSIONS

Values and Food Production Paradigms

As described in the introduction, the past three decades have seen a slow but steady revolution in Europe in terms of the preferred production mode for food. The dominant agri-industrial food production system is challenged by the more environment-friendly and grass-root initiated post-productivist model. This shift is less about change in production processes and more about changes in values systems. One could place it along the well-described shift from materialist to post-materialist value orientation that is evident in European societies in the last decades.

This value shift can be superimposed on the ethical continuum of Utilitarianism and Deontology. The obvious utilitarian gains of the agri-industrial model are becoming less significant than the sustainability and wellbeing gains of the post-productivist model. It seems that society is looking beyond the material gain in quantity and price in food and, as in Maslow's pyramid, attempts to incorporate "higher" values that are required to actualise societal inspirations. These values are entrenched in the process of governance in Europe through its various treaties as Justice, Freedoms, Rights, Sustainability, Dignity, Solidarity and Equality. Our research has shown that some of these values are pivotal in the discourses on Food Technologies and they influence the arguments and perceptions that stakeholders hold.

The Three Main Discourses

The debate we witness in Europe in the area of Food Technologies covers the whole spectrum of the analytical framework that GEST is covering both in terms of discourse theme and in terms of the main societal values as they are described in the European legal documents. The discourses on Innovation, Risk and Power & Control have certain overlaps in terms of argumentation as one might expect in every discussion on highly complex scientific issues that affect lay perceptions and deep individual sentiments. Food is a par excellence issue in that respect as it represents science and lifestyle in equal measures in policy debates. As such, the discourse on Innovation and its focus on economic prerogatives cannot be clearly delineated from that of Risk with its focus on individual effects or for that matter from that of Power & Control that attempts to balance the two in a socially sustainable manner.

Similarly the categorisation of the main discourses in the dominant values system will inevitably suffer from delineation impracticalities since the values themselves are used more as guiding principles rather than defined legalistic concepts. The values of Justice, Equality, Sustainability, Freedoms and Rights that are dominant in European societies show significant overlaps (and even contradictions) when it comes to real life applications. Nevertheless, it is neither counterproductive nor undesirable to attempt a categorisation of a scientific debate in terms of values and discourses. It is needed in order to achieve certain clarity of source and purpose in the debate process and Food is a particularly appropriate issue to fit such categorisation.

The following matrix summarises the main arguments in terms of dominant value and type of discourse in Food Technologies.

	Justice/Equality	Sustainability	Freedoms/Rights
Innovation	**Economic Development; Health Benefit Effects; Unaffordable Products**	**Disease resistance, Extreme Climate Crops; Bioenergy Crops**	**Choice between Agri-Industrial and Post-productivist Products**
Risk	**Adverse Health Side-effects**	**Crop Cross Pollination**	**Monopoly Market; Lack of Choice**
Power & Control	**Substantial Equivalence; Precautionary Principle**	**Food Security; Food Monopoly; Crop Co-existence**	**Labelling of GM Products**

Justice/Equality

We will take a value perspective in describing the matrix as this is most related to the theme of GEST as an ethics focused project. Justice and Equality are combined here since the overlap in the relevant argumentation is sufficient to make them indistinguishable from each other. Both refer to the attempt to uphold fairness in societal dealings, free of prejudice or preference of treatment for one group over another. As we have seen, the Innovation discourse that is based on these values (not necessarily referring to them directly) deals with two main arguments. The most straightforward one deals with the opportunity that the new Food Technologies provide for economic development and therefore prosperity for the whole society. This is an argument that is promoted for almost any new technology, the difference here being that the European food industry is such size that failure to adopt the new technology will have dire consequences for a great number of people (employees or consumers) regardless of their social status. Equality as interpreted in this case in terms of access to work and food products for all, will be affected. Similarly, the argument goes, stopping a technology that can have direct health benefit effects runs contrary to our values of Justice and Equality, interpreted here as fair and equal access to wellbeing. The contrary argument sees an increase in Injustice and Inequality with new technology products that are prized higher than the equivalent “less healthy” ones and therefore being unaffordable for the less-well-to-do citizens.

The Risk discourse under these values focuses on rather technical details that any new type of food would raise, namely, whether it carries any risks to human or animal health. This discourse being the most fact-oriented one, is also the least conclusive in terms of values. Justice and Equality would prohibit the unnecessary taking of risks, particularly if these relate to specific groups. Here the argument states that Food Technologies (i.e the specific ones we’re dealing with) represent a huge risky experiment with the health and wellbeing of all citizens, therefore breaching the value of Justice in oppressing people to become experimental subjects against their own will.

The Power & Control discourse is the eventual battleground where Justice and Equality are enshrined in law. Here we have seen the interplay between two different arguments relating to risk assessment: substantial equivalence versus the precautionary principle. At a sufficient macro-perspective (I.e that of global debates) substantial equivalence provides a just and equal for all risk assessment process and its abandonment creates unfairness and inequalities in international relations. The opposite might be considered true for the precautionary principle at a micro-perspective (i.e. that of the individual society): it promotes fairness and equality for the citizens that do not agree with the status quo and are unwilling to become “research subjects” as described above.

Sustainability

As explained in the State-of-art report, the value of Sustainability refers mainly to environmental protection but from an anthropocentric view, meaning the upkeep of a nice environment for use by people of this and next generations. In that perspective, Sustainability in terms of Food Technologies relates to the way the food is produced and the reason for which it is produced. The Innovation discourse revolves around the specific characteristics of food crops and their relationship to the environment. For instance, the main arguments here promote these new technologies as a way to withstand environmental threats (diseases) and conditions (extreme climate) that otherwise would be impossible or too costly to achieve. As such, these technologies promote a cleaner and more sustainable environment. The same argument goes for the creation of bio-energy crops that could save the environment from existing polluting energy sources.

The risk discourse in Sustainability deals mainly with the issue of affecting the existing environmental by introducing alien crops that are impossible to separate from the current ones. Cross pollination appears to be inevitable and as a result the threat of diminished biodiversity and decreased sustainability is real.

As with the previous values, the Power & Control discourse is also the central battleground for the main arguments. In this case, the main policy issue is whether the existing environmental conditions are sufficient to produce a sustainable source of food for the increasing human population or not. Food security requires new ways of thinking on how to use the environment sustainably for the benefit of human kind and the new food technologies offer such possibilities. At the same time, the fact that these technologies are dominated by a small number of profitable enterprises could create the opposite effect: a world where biodiversity is dwindling while what remains is governed by few. It is also doubtful that a “sharing” solution can be found, whereby both types of crops can be grown next to each other (co-existence), since there is inadequate knowledge and many legislative hurdles to deal with compications.

Freedoms/Rights

The values of Freedoms and Rights are so closely linked that they become almost interchangeable in scientific debates. Freedom to choose between various technologies is similar to the right to have a choice over the same technologies. In the Innovation discourse on food technologies both proponents and opponents promote similar argumentation that the citizens should have the right and the freedom to choose between products deriving from either agri-industrial or post-productivist types of agriculture. This usually, but not always, translates into choices between organic and non-organic foods in the European supermarkets, although there is a wider spectrum of production methods that fit one or the other type. What distinguishes the arguments is not the matter whether choice should exist but how society should achieve it. Labelling issues are closely related to this argumentation but belong to another discourse.

In terms of the Risk discourse guided by the values of Freedoms and Rights, one can find the rather sensitive (politically speaking) issue of Intellectual Property Rights. IPR in new food technologies can have significant effects in market availability and since food is essential to every society, IPR issues can create dangerous market shifts. For instance, extensive IPR protection could lead to monopolies while weak protection could lead to lack of innovation. As with other similarly essential industries (e.g. pharma), the Risk discourse

in terms of Freedoms and Rights has taken a distinctive international character with not easily reconcilable perspectives.

The Power & Control discourse in Europe has concentrated mainly on the issue of labelling, whereby the Freedom to choose is associated with the Right to know. Despite considerable opposition by the food industry, labelling of products containing GM ingredients has been viewed as a basic Right and has been legislated as such. The only undecided issue is the level of tolerance for new technology (i.e. GM) ingredients that is acceptable for labelling purposes.

Reflective Ethics and Lay Morality

When it comes to reflective discourses like that of Ethics or Public discourses, dominant values are not easily distinguishable in the debate since they permeate all argumentation. We have established that one can better describe reflective discourses with a traditional approach to ethics discourse analysis that includes the description of stakeholder perspectives in terms of ethical principles. This analytic approach, termed "ethical matrix" is inspired by the "principled approach" in standard bio-medical ethics (Bhuiyan, 2010).

Food Technologies Ethical Matrix

	Beneficence	Non-Malfeasance	Justice	Autonomy
Innovator	Profitability. Advance science. Positive impact on Global Food Security.	No damage to reputation. No adverse market effects.	Respect of IPR. No unfair regulation or competition. Protection against trade barriers.	Freedom to develop, exploit and market the innovation.
Primary Producer (Farmer)	Profitability. Improved and/or more reliable yields. Better product consistency. Reduced production costs.	No increased heath or other risks to themselves, customers or end users. No environmental damage. No adverse animal welfare issues.	Ability to establish equitable trade deals with suppliers and customers. Regulations that provide a level playing field.	Ability to choose which crops and stock to farm. Ability to change product or supplier if market conditions change.
Secondary Producer (Manuf/Distrib)	Increased profitability. Improved product quality and company reputation.	No contaminants in products. No risks to health or the environment. Labelling of potentially harmful product components (e.g. allergens). Non-misleading marketing.	Ability to trade and market freely under equitable regulation. No unreasonably burdensome regulation.	Ability to freely choose suppliers, production methods, marketing and labelling strategies.
Consumer	A pleasing product in	Food Safety. No adverse	Effective regulation and	Ability to choose or not

	terms of quality and sensory characteristics, that fosters good health and well-being. Affordability. Convenience. Availability. Fosters social interaction.	health benefits. No adverse impact on the environment from either the product, its manufacture or wastes. No adverse animal welfare issues.	risk analysis. Appropriate use of the Precautionary Principle. Fair trade and avoiding unfair competition. Provision through advertising and labelling of the *necessary* and accurate information on product, source, ingredients, manufacturing processes and any established benefits or potential hazards. .	to choose a product produced using an innovative technology. Choice may be based on factual information or on perceptions. Effective and adequate labelling to enable an *informed* choice including a risk/benefit choice.
Environment	Improved sustainability of individual species and ecosystems. Improved recycling. Reduction in environmental contamination.	No unsustainable use of environmental resources. No increase in contamination by innovations, their production or their waste materials.	Sustainability built into innovation exploitation. Effective environmental regulation. Environmentally neutral impact.	Maintaining the *balance of nature*. Maintenance of *Telos*.

The ethical matrix analysis above identifies stakeholders' perspectives on fundamental ethical principles, both inward-facing, as they relate to themselves and outward-facing in terms of their ethical responsibility to other stakeholders and wider society. It is possible that these different perspectives might in some cases be conflicting, even for a single stakeholder. Therefore an important consideration is the values held by each stakeholder as this could affect the way in which individual stakeholders balance what they perceive as their own interests with those of other stakeholders. This is particularly important where the interests and/or perspectives of different stakeholders appear to conflict. For example, the innovator whose primary focus is on their own freedom to innovate and market their inventions in a way that maximises financial gain while avoiding any negative impact on their brand or image may well find themselves in conflict with other stakeholders, who may see a right to open and transparent information as an essential factor in their freedom to choose and make decisions relating to a new innovation. Farmers who focus on their freedom to choose whether or not to grow GM crops or animals may find themselves in conflict with other stakeholders who prioritise protection of human health, the environment or animal welfare and who perceive GM products as having unidentified potential risks. An example might be a farmer who wishes to grow GM crops in an area in close proximity to

another farmer growing organic crops which may then be at risk of contamination through cross-pollination with the GM organisms.

Thus an important factor for all stakeholders is to understand not only their own needs but also the needs and perspective of other stakeholders with whom they need to interact. Without an effective balance in the ethical perspectives of all stakeholders, novel innovations may stall through opposition or companies may be dis-incentivised from developing certain new technologies. This is, to a large extent what has happened following the European GM debate and is still a major factor blocking its introduction into the European food chain. Innovators and manufacturers believe that they should have the right to develop and market GM products. One argument used is that GM products can increase the food supply and strengthen food security particularly in the developing world. However these are poor arguments for introduction of this technology into a region such as Europe where food is plentiful and consumers expect to make their own choices about the food they eat and see no reason for exposing themselves to any level or potential risk when there are no evident benefits. It might be argued that in a country suffering chronic food shortages consumers will have few concerns about whether or not the food available to them is genetically modified or not. It is questionable as to whether this is in fact true as a number of developing countries have also expressed strong concerns about GM foods. While it is true that, in line with Maslow's Pyramid of Needs, if people are struggling to meet their basic physiological needs and perhaps have only one source of food, they are unlikely to reject food from whatever source it comes, this does not mean that any concerns they may have can be ignored. However as individuals in societies increasingly have their basic physiological and safety needs met they have greater opportunities to express the ethical principle of autonomy or freedom of choice. They are also likely to have greater opportunity and perhaps inclination, to express more outward-directed or altruistic choices, for example in relation to other communities, animal welfare or the environment.

It is argued by some innovators and policy-makers that the benefits associated with GM foods are increasing and that consumer acceptance of GM products would lead to important economic growth. While there is some evidence that consumers are more likely to accept GM products if benefits can be clearly identified, the broader economic growth argument is likely to be outside the interest of most consumers in their everyday lives. While other stakeholders are well aware that consumer acceptance is the key to the success for their innovations and products in the market, they have repeatedly failed to understand or accept the perspectives and values that drive this consumer acceptance, choosing instead to insist that if consumers just understood the science or trusted them to explain it, all would be well. Patently this approach does not work. So what is it that consumers particularly in a European context, need to hear? Above all else, European consumers appear to value their freedom to choose which products they will buy and this is particularly true in relation to food. Although there is general recognition that providing consumers with information on real and potential risks and benefits associated with GM foods in general is important, this alone is not sufficient to secure consumer acceptance. A key issue of conflict in the GM debate is the insistence by European consumers that they should be able to make an informed choice on individual food products by having those containing GM to be labelled as such and a great reluctance on the part of manufacturers to attempt to market products for which this would be a requirement. A major concern of manufacturers is that consumers would reject foods labelled "GM" while the consumer perceives the lack of willingness to market products labelled "GM" as evidence of undisclosed risks which in turn reduces trust and strengthens their perception that GM products are unsafe. A better understanding of and willingness to address stakeholders fundamental ethical concerns and values and wherever possible find common ground, is crucial not only for GM foods but for the success of any novel innovation into the market.

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ANNEX 1 – GM TECHNOLOGY STATE-OF-ART

GM modification of plants to improve nutritional value to humans (foods) and animals (feeds) has also been the subject of considerable scientific interest. For example, introduction of antifungal genes into plants can increase their resistance to fungal infections that produce mycotoxins. As mycotoxins can be toxic to animals and have carcinogenic properties, which may have negative impacts on animal and human health, this development could provide food safety benefits. Research has also been carried out to increase the nutritional value of crops by enhancing their photosynthetic capabilities, either through modification of the light-gathering and trapping capacity or by modifying directly the process of photosynthesis. Plants produce many proteins and amino acids which contribute to human nutrition and health. Indeed some essential amino acids can only be found in certain plants. Genetic research has been looking at the possibility of modifying certain plant genes to cause them to produce modified proteins with an increased level of certain amino acids which are important for human nutrition. Work of this type has been carried out, for example, soybean, maize, canola, sunflower, brazil nuts, rice and sweet potato. There are, of course, important safety considerations that must be taken into account, in particular potential toxic or allergic effects of any artificial or modified proteins must be carefully and fully assessed before the commercial viability of such products could be considered. Other GM applications in plants include flavour enhancement in crops such as tomatoes (Minkel 2007), to enhance appearance (Yamin 2003) or to extend shelf life (Matas et al 2009)

One particularly interesting area of the application of GM to plants is to produce a range of useful molecules, which can not only increase the yield and nutritive capacity of the plant but also enable the production of pharmaceutical substances including proteins (such as insulin and hirudin), antibodies, and vaccines. There are many examples of vaccines being successfully produced from plants including human vaccines that induce immunity against cholera, E coli, Norwalk virus and rabies as well as animal vaccines that are effective against foot and mouth and other animal diseases. The ultimate objective is to produce edible vaccines that would be effective against enteroviruses and bacteria in particular (Slater et al, 2008). Work has also been done on the development of biodegradable plastics from genetic manipulation of plants (Scheller and Conrad 2005).

Other developments include the use of GM in Precision Agriculture. Precision agriculture aims to improve environmental sustainability by enabling more targeted use of agricultural chemicals and identification of adverse factors on crops (Bongiovanni and Lowenberg-Deboer, 2004). Increasingly, this involves monitoring of crops using real-time satellite imagery. Such convergent technology is used to enhance precision agriculture. An example of this is the insertion of a luminescent jellyfish gene into crops. The jellyfish glows blue when exposed to free calcium ions. As calcium ions are released when plants cells suffer damage, when these crops are damaged by pest, disease or environmental factors the jellyfish gene causes them to glow (Chaerle et al, 2002). Use of ICT and satellite technology enables the glowing areas of crops to be quickly identified and targeted remedies applied quickly and with the minimum environmental impact. This can be particularly useful where very large areas of crops are growing and identification of small areas of damage can be difficult to spot.

Despite the wide range of potential applications of GM modification of plants described, there has in practice been relatively little diversification of GM traits in plants. The main focus for applications continues to be on herbicide tolerance and pest resistance and its refinement, with the main species being developed being soybean, maize, cotton and oilseed rape. Several important anticipated developments such as disease and stress

resistance appear to have foundered at the pre-commercialisation stage and little advance has been made with the main global food crops such as rice and wheat (Slater, Scott and Fowler 2008).

In addition to the application of GM technologies in plants, there is an increasingly active research agenda in relation to GM animals. The possible use of genetic modification in farmed animals (both aquatic and terrestrial) spans a wide range of potential applications including the development of larger and more productive animals for the agri-food sector which would result in increased economic benefit, applications in the life sciences to develop pharmaceutical products to enhance human and animal health and applications to reduce environmental impacts, improve animal welfare and sustainable production.

Some of the following text is derived from Frewer et al (2013). Data from the scientific literature, patents and experimental permits (Houdebine, 2011), suggest that the techniques available to generate GM animals have improved considerably and so development costs no longer represent a major barrier to the development of transgenic animals, whether for food-related or medical applications. One consequence is that the cost of genetically modifying larger animals is no longer prohibitive. For example, models for the study of human diseases can now utilise GM pigs as well as GM mice, allowing for more sophisticated analysis (Laible, 2009; Houdebine and Jolivet, 2011; Prather et al, 2008) and animals have been used (although not licensed) to develop organs for xenotransplantation to humans (Klymiuk, 2010).

Advances in research into GM farm animals have resulted in foods derived from these animals having enhanced quality or production yields (Laible, 2009) or nutritional value (*e.g.*, Maclean, 2003; Lock and Bauman, 2004) A major problem in conventional breeding remains that of animal diseases, which results in stock loss, animal welfare problems and threats to human health. Chickens resistant to influenza virus (Lyall et al, 2011) and (potentially) pigs resistant to Aujeszky disease (Ono et al, 2004) provide good examples of breeding improvements using animal genetic modifications. Changes to foodstuffs may be implemented to meet the needs of individuals with specific dietary requirements, such as the modification of milk fat composition to enhance fatty acids (Muyssen, 1989). Developments are thus intended to improve food security or human health, although the benefits and long-term impacts on agricultural sustainability are difficult to predict (National Research Council, 2002). The most technologically advanced projects are related to the expression of bioactive compounds such as human lactoferrin (Yang et al, 2008; Brundige et al, 2010) in bovine milk and the production of meat enhanced with omega-3 fatty acids through the expression of roundworm desaturase gene in transgenic pigs (Lai et al, 2006). However, the most direct application of the genetic modification of animals which may bring benefits to public health is the production of therapeutic recombinant proteins (Houdebine, 2006; Houdebine 2009), and GM animals have been used for production of specific proteins for treatment of various health problems such as blood disorders (thrombosis and haemophilia), hereditary angioedema, osteoporosis, and emphysema (Moura, 2011).

The use of GM animals for the production of pharmaceuticals is relatively efficient, but only rarely applied in a commercial context, in particular by pharmaceutical companies. This, in part, may be a consequence of industry concerns about the societal acceptance of genetic modification although there is evidence that the public view genetic modification of animals for medical purposes very differently than their use in the food chain (Frewer et al, 2013). However, there may be other commercial reasons underlying this observation. Pharmaceutical companies can potentially be in competition to produce pharmaceutical proteins, and so need to have strong reasons to promote the production of pharmaceutical proteins by GM animals, which might broaden competitors' access to the same compounds. Despite this, there is greater investment in the use of GM animals in the medical and pharmaceutical sectors compared to the food sectors, with three major

countries developing GM animals namely China, Argentina and the USA [REF]. In comparison, the EU is less advanced scientifically (Vàzquez-Salat et al, 2012). The technical potential and scientific resources for the production of GM animals in the EU is high, but the number of supported projects remains very low compared to those in other regions of the world (see Frewer et al, 2013).

The on-going discussion about GM crops (Horlick-Jones et al, 2007), and the developing debate about the safety and ethics of foods and pharmaceutical products produced by both GM animals and plants, have provoked varying views across different sectors of society (*e.g.*, see Frewer et al, 2004; Knight, 2009; Pivetti, 2007). At the time of writing, while no GM animals have been approved for food use in Europe or the US (Kleter and Kok, 2010), this is not the case for pharmaceuticals derived from GM animals (Houdebine, 2009; Kling, 2009). Medical application is more widespread internationally, with research focusing on applications of GM animals in the study of gene function and human diseases, or as a source of therapeutic human antibodies (Houdebine, 2011).
The use of GM animals in agriculture may potentially present greater challenges than medical applications because there are greater demands related to consumer acceptance of process and products, the relative value of the product is less within the agricultural sector, and animal welfare concerns related to farmed animals may arise. In addition, production of GM animals for agriculture is a less efficient process than is the case for medical applications *Frewer et al, 2013; Labile, 2009). These potential barriers to commercialisation have frustrated many scientists keen to bring applications to the commercialisation stage (Moon Chapotin , 2007; Vàzquez-Salat et al, 2013).

However, independent of whether a specific application of GM animal is licenced for use in a particular region or country, regulators may also need to consider the possibility that agri-food applications of GM animals may enter the food supply chain through imports from overseas (Howard et al, 2001). For example, the EU is the world's largest international trading block for food commodities (European Commission, 2012). Importing goods from countries and regions which operate different regulatory approaches to commercialisation of GM animals may result in accidental or fraudulent inclusion of GM animals in the European food supply chain (Frewer et al, 2013). The recent discovery of beef in Europe either containing or being contaminated by horse meat or horse DNA demonstrates how easily this can occur unless very specific testing is in place. Progress in reducing or eliminating potential inconsistencies across jurisdictions, and harmonising international regulations, is slow. Despite this, commercialisation of the products of GM animals, whether applied to agriculture or pharmaceutical production, is fast becoming a reality. Appropriate evidence-based governance frameworks, which take account of all relevant factors, are required, and these need to be contextualised by understanding of societal responses to emerging technologies such as GM animals used in agricultural and pharmaceutical production. This information is needed to optimize and regulate strategic development of, and communication about, GM animals, as well as to develop and refine commercialisation strategies associated with specific GM products whether plant or animal (see Frewer et al, 2013).

Nanotechnology Innovations in the Food Chain

The following is adapted from Coles and Frewer, 2013 (submitted). Below a number of key areas of nanotechnology application in the field of food and agriculture are provided, together with some specific examples within each area.

Agricultural practice

There has been significant investment in agricultural applications of nanotechnology aimed at addressing some of the limitations and challenges facing large-scale, chemical and capital-intensive farming systems (Scrinis and Lyons, 2007). These include improvement of the efficiency of soils and other growing media and facilitating targeted delivery of both nutrients and pesticides. Specific current and potential applications designed to improve the fertility and capacity of soil and other growth substrates, include the fine tuning and more precise micro-management of soils; more efficient and targeted use of inputs such as fertilisers and other soil additives (Scrinis and Lyons, 2007); use of nano-iron and carbon nanotubes for soil and water remediation and purification (Karn et al, 2009). New substances are also being formulated for more effective pest control, including smart pesticides some of which would have the capacity to respond differentially to a range of pests including targeted action through smart sensors and smart delivery nano-systems (Rai and Ingle 2012). Another agricultural application is the incorporation of nano-sensors into livestock to facilitate animal tracking, drug-delivery systems or to detect presence of certain substances such as drugs, growth hormones etc. when animals are marketed (Nguyen et al, 2012).

A further possibility is the use of nanotechnology in nano-induced changes to plants and animals for the development of new crop and animal traits and behaviours. Work has also been carried out on the use of nano-encapsulation as a method of facilitating vaccination of fish stocks. The encapsulated vaccine is released into the water but only released from the micro-capsule once ingested by the fish (Nielsen et al 2011)

Research on the nano-modification of seeds (precision GM) raises the possibility of the use of nanotechnology as an enhancer of genetic modification. Although still in its very early stages it has the potential to enable very precise genetic modification of seeds (Scrinis and Lyons 2007). This precision GM could then potentially also be extended to animals.

Food manufacture and processing

Many large scale manufacturers of foods and agricultural products have already invested heavily in nanotechnology R&D and indeed nanotechnology is already being used in some countries in the production of agricultural products as well as processed foods and drinks (Scrinis and Lyons, 2007) and in food packaging. In the manufacture and preparation of food, nano-sieves are already in use for nanofiltration applications (Erikkson 1988), use of nano-materials to create non-fouling surfaces in food preparation prevents clogging of processing machines and therefore reduces the need for both cleaning and machine downtime and so lowers production costs. Research is also underway to develop fibrillar protein aggregates as meat replacers and nanotechnology may be one route to enable fibrillar proteins to be constructed to imitate meat. Nanotechnology can also improve the texture of foods such as making them taste creamier (e.g. texture of dairy products such as yogurts and ice-cream),

Food packaging

The application of nanotechnology to food packaging is of great interest to manufacturers and retailers and is an area where nanotechnology-derived materials have already been introduced to improve mechanical and barrier properties. Packaging applications includes use of nano-silver as a microbicide to extend the freshness of food and prevent contamination (Maillard and Hartemann 2012). Nano-materials can also be used to improve the barrier properties of packaging to regulate the passage of gases and moisture through the packaging to extend shelf life and maintain quality and freshness (Sozer and Kokini 2009). Nanotechnology can also improve the biodegradability of packaging (Sozer and

Kokini 2009), and together with the development of stronger and less bulky nano-packaging; this could generate less waste. Nanosensors are also being developed to detect both the ripeness of packaged products and also the presence of pathogens (Kuswandi et al, 2011). These are likely to be in the form of buttons on the packaging which change colour. A further development of this approach could also be used to signal whether the packaged food is displayed or stored at the optimum environmental conditions.

Food Products, supplements and additives

Nano-encapsulation (foodstuff is encapsulated in a nano-material that protects it from gut digestive juices until it reaches its target which it identifies by surface interaction) and increased bioactiviation (where a nano-substrate can be used to optimise the way a bioactive ingredient is presented to its target) are important elements in the development of novel foodstuffs, particularly functional foods and nutriceuticals for the delivery of drugs to specific sites or for oral vaccines. Increased bioavailability through nanocrystals would enable e.g. omega-3 fatty acids, phytosterols, flavours, antimicrobial components, antioxidants and carotenoids such as β-carotene and lycopene to be absorbed more effectively where they are needed. Targeted nutrition increases the rate of uptake of nutrients during digestion while nano-encapsulation could also reduce the uptake of e.g. fats, thus allowing delivery of the flavour of fats without their calorific or other undesirable effects. An alternative nanotechnology approach could modify flavour delivery so that non-fatty foods might taste fatty.

Some delivery systems for biologically active compounds are already available in some countries. For example in Germany nanotechnology is used in foods and dietary supplements to produce *inter alia,* nano-green tea, to improve the bioavailability of selenium from the leaves, “Canola Active” cooking oil with microencapsulate phytosterols to reduce absorption of cholesterol, nano-vitamins and nano-coenzymes (Sekhon 2010).

References Annex 1

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ANNEX 2 – STRUCTURE OF FOOD ETHICS ADVISORY IN EUROPE

As described in detail in the State-of-Art report (D1.1), policy advisory in Europe is well embedded in the decision making process although not clear in terms of its ethics remit. Most major Government incorporate advisory bodies that deal with technical/scientific issues and some Departments have their own research ethics committees. When it comes to strategy and policy in general, the existing advisory bodies deal mainly with risk assessment and communication issues that include socio-ethical questions indirectly.

When it comes to Food Technologies, risk is also the main preoccupation while ethics deals with communication issues rather than value orientation. We will provide a short description of the main advisory bodies in the European Union and the three countries (UK, Germany and The Netherlands) that are represented in GEST, in order to view the extend and remit of the official policy advisory in this field.

European Union

The European Food Safety Authority (EFSA)

EFSA is the main policy advisory organisation at the level of the European Union[1]. It was set up in January 2002, following a series of food crises in the late 1990s, as an independent source of scientific advice and communication on risks associated with the food chain. The creation of EFSA signified a strong will by the EU to centralise food related policy discussions and provide a common front in food safety and consumer protection in the region. As risk assessor, EFSA produces scientific opinions and advice to provide a sound foundation for European policies and legislation and to support the European Commission, European Parliament and EU Member States in taking effective and timely risk management decisions. EFSA's remit covers food and feed safety, nutrition, animal health and welfare, plant protection and plant health. In carrying out its work, EFSA also considers the possible impact of the food chain on the biodiversity of plant and animal habitats. The Authority performs environmental risk assessments of genetically modified crops, pesticides, feed additives, and plant pests.

Risk communication is a key element of EFSA's mandate. It takes the form of risk perception analysis (mainly through Europe-wide public perception surveys) and communication activities with media, main stakeholder groups and other similar national food advisory organisations. Ethics analysis is not included in the remit of EFSA but lay morality, as reflected in surveys, is taken into consideration in its communication strategy. It should be fair to say that communication is not EFSA'a strong point and it is considered a typical scientific organisation that the European media would not necessarily turn into in the first place in order to get guidance in their stance on foods. Moreover, the values that EFSA prioritises in its work are those of transparency, openness and independence that are key scientific research values and not policy values as we consider in GEST.

United Kingdom

[1] For a full description of EFSA see http://www.efsa.europa.eu

The Food Standards Agency (FSA)

The FSA is an independent Government department set up by an Act of Parliament in 2000 to protect the public's health and consumer interests in relation to food[2]. The agency is responsible for food safety and food hygiene across the UK. It is a non-Ministerial Government Department led by a Board rather than directly by Ministers. The Board comprises a Chair, Deputy Chair and between eight and twelve ordinary members of whom one is appointed by the Welsh Health Minister, one by the Northern Ireland Health Minister, two by the Scottish Health Minister and the remainder by the Secretary of State for Health.

The FSA provides advice and information to the public and Government on food safety from farm to fork. It also protects consumers through effective food enforcement and monitoring. It works with local authorities to enforce food safety rules and have staff who work in UK meat plants to check that the requirements of the regulations are being met. The FSA represents the UK Government on food safety and standards issues in the European Union and it is also involved in the nutrition and health agenda at a European level. It functions as information provider to the public and undertakes regular public consultations to help it structure its work plan. Socio-ethical analysis in food issues is only indirectly dealt with in the organization through its consultation activities that aim to include stakeholder perspectives and general public opinions.

The Food Ethics Council UK

The Food Ethics Council is a charity that provides independent advice on the ethics of food and farming[3]. The organisation was established in 1998 with support from the Joseph Rowntree Charitable Trust and the Farm and Food Society. Its work is funded by donations from foundations and individuals and also by selling publications, organising events and undertaking research. Commissioned work is accepted when organisational independence is guaranteed.

The work of the organisation is based on the traditional values of fairness and individual rights and as such it undertakes ethical analysis of food issues. A major tool employed in the work of the organisation is that of the Ethical Matrix that is designed to analyse purely ethical perspectives in any given issues by incorporating stakeholder arguments in relation to established ethical principles. The ultimate aim is to promote ethical decision making in food policy.

As such, the Food Ethics Council is the par excellence organisation in food ethics advisory although its influence in policy making is not to be taken for granted. As the Council is neither dealing with risk assessment nor with risk communication and due to its limited funding and distance from government departments, their advice is not widely circulated or debated in food policy circles.

The Nuffield Council

The Nuffield Council on Bioethics is an independent body that examines and reports on ethical issues in biology and medicine[4]. It was established by the Trustees of the Nuffield

[2] For a full description see http://www.food.gov.uk/

[3] See also http://www.foodethicscouncil.org/home

[4] See also http://www.nuffieldbioethics.org/

Foundation in 1991, and since 1994 it has been funded jointly by the Foundation, the Wellcome Trust and the Medical Research Council.

The Nuffield Council has an international reputation for advising policy makers and stimulating debate in bioethics. Its reports are widely circulated in the UK and appear as reference points for all relevant bioethics debates in the country and beyond. Moreover the Council, due to its international status, represents the UK in international networks of National Ethics Bodies, thereby being the de facto UK National Ethics Council.

The Council deals with the whole spectrum of S&T and it is not required to adopt the same ethical framework or set of principles in all reports. It is therefore not bound by the values of particular schools of philosophy (for example, utilitarianism, deontology, virtue ethics) or approaches in bioethics, such as the 'four principles of bioethics' (autonomy, justice, beneficence, non-maleficence), or the Barcelona Principles (autonomy, dignity, integrity, vulnerability).
Due to its wide remit in bioethics, the Nuffield Council has provided opinions on genetically modified organisms and food ethics issues. These are the standard reference points for the ethics debates at national level.

The Netherlands

The Netherlands Commission Genetic Modification

The Netherlands Commission on Genetic Modification (COGEM) advises the government on the potential risks of genetic modification to human health and the environment[5]. The scope of COGEM covers all fields, ranging from agriculture to medicine and from contained use to deliberate release of GMO's. However, COGEM solely advises on environmental risks and does not advise on food safety, animal welfare, or patient safety (e.g. in relation to gene therapy). In addition to scientific advice on risk assessment, COGEM brings ethical and societal issues related to genetic modification to the attention of the relevant Ministers.

COGEM advises both independently and at the request of the Ministry of Infrastructure and the Environment. COGEM has three scientific subcommittees. One of these is the subcommittee on Ethics and Societal Aspects. This subcommittee identifies ethical and societal aspects related to genetic modification. Particular attention is paid to the deliberate release of GMOs into the environment and the market introduction of GMOs. However, COGEM does not issue any political or policy recommendations with respect to these matters. The commission sets out the various arguments to facilitate a balanced decision-making process, which systematically takes the various arguments into account.

The Health Council of the Netherlands

The Health Council of the Netherlands (Gezondheidsraad) is an independent scientific advisory body whose task is to advise ministers and Parliament in the field of public health and health/healthcare research[6]. Ministers ask the Council for advice which they can use to substantiate policy decisions. The Health Council also has an "alerting" function: it can also give unsolicited advice. Both the solicited and the unsolicited advice serve as a scientific substantiation for the ministries' development of their policies. The Council carefully charts

[5] See http://www.cogem.net/index.cfm/en/cogem/
[6] See http://www.gezondheidsraad.nl/en

the latest scientific knowledge and compares the different options for efficiently improving public health.

The Council has recruited some 200 experts to respond to the requests for advice and works on a case-by-case basis within ad hoc committees. These committees are made up of Council members who are specialists in the relevant field and of experts who are not members of the Health Council. Together, these experts aim to reach consensus on the interpretation and weighting of the current level of knowledge. Draft reports are assessed by one of the eight standing committees before being presented to the relevant minister. The Council has produced a number of reports on GM related issues, such as on the Insect-resistant and herbicide-tolerant maize.

The Rathenau Instituut

The Rathenau Institute is an autonomous organization, which was founded by the Ministry of Education, Culture and Science in 1986 and functions under the Royal Netherlands Academy of Arts and Sciences[7]. Rathenau promotes the formation of political and public opinion on science and technology. To this end, its Technology Assessment department examines the social impact of new technologies and organizes debates on issues and dilemmas in science and technology. Rathenau tends to stimulate political opinion making of the Dutch House of Representatives, the Senate and the European Parliament.

The Technology Assessment department is also specifically concerned with examining the ethical issues that S&T may give rise to, including new biotechnologies, Nanotechnologies, GM crops and food, etc. Furthermore, Rathenau is responsible for the Platform on Science and Ethics (Platform voor Wetenschap en Ethiek) that aims to provide open access for society on ethical considerations related to science and technology.

The National Institute for Public Health and the Environment (RIVM)

RIVM is a specialised Dutch government agency with a remit is to modernise, gather, generate and integrate knowledge and make it usable in the public domain[8]. RIVM contributes sustainably to promoting the health of the population and the environment by providing protection against health risks and environmental damage. A main theme of focus is GM in the food chain with a number of reports such as: General surveillance of genetically modified plants : Possibilities for implementation in the Netherlands & Genetically modified ornamental fish in the Netherlands. 'A glowing problem?'

Germany

German Ethics Council

[7] See http://www.rathenau.nl/en.html

[8] See http://www.rivm.nl/en/

The German Ethics Council ("Deutscher Ethikrat") has replaced, since 2007, the original National Ethics Council ("Nationaler Ethikrat") that was founded in 2001 in Germany as a national forum for dialogue on ethical issues in the life sciences. Its members are appointed by the President of the German Bundestag with a mandate to orient the discussion of ethical issues towards legislative action[9]. At the same time the mandate of the Council is to "inform the public and encouraging discussion in society, engaging the various social groups" thereby making it a unique institute that promotes social dialogue that should lead to legislative initiatives.

One of the main themes in the work of the Council is Agriculture and Nutrition whereby GM and cloned foods have been the focus of deliberation. The reports of the Council are discussed in Parliament and are widely distributed to academic, research and NGO national networks.

Office of Technology Assessment at the German Parliament (TAB)

The Office of Technology Assessment at the German Bundestag (TAB) was founded in 1990. Its tasks and activities include the design and implementation of TA projects[10]. TAB also monitors and analyses important trends in science and technology and related societal aspects, including technology foresight, analysis of international policies, and research into the innovation of new technologies. TAB has conducted research on more than 100 topics dealing with highly contested and ethically sensitive issues such as Biotechnology, Human Genetics and Biomedicine, Nanotechnology and GM Food.

The aim of TAB is to supply the German parliament with information, providing a scientific basis for the policy-making process. The institutional setting provides for a strict separation of competences of politics and science. The parliamentary committees (steered by the Committee for Education and Research) decide about the issues to be dealt with by TAB and about the political conclusions to be drawn from TAB's reports. The scientific unit, made up of 10 scientists is funded by the Parliament but all scientific decisions are taken independently by TAB.

Institute for Technology Assessment and Systems Analysis (ITAS)

The Institute for Technology Assessment and Systems Analysis (ITAS) was founded in 1995 as a successor of different institutions and is a research facility of the Karlsruhe Institute of Technology (KIT)[11]. ITAS is the largest and most long-standing scientific institution in Germany dealing with TA and systems analysis in theory and practice. ITAS is involved in the research program of the Helmholtz Association of German research centers (HGF) in particular the program "Technology, Innovation and Society". ITAS is assessing technological impacts and comprehensive systemic interrelations of societal transformation processes and developments in science, technology, and the environment. The results of research and policy advice are publicly available.
ITAS is divided into four research areas: Sustainability Development and Environment, Energy - Resources, Technologies, Systems; Innovation Processes and Impacts of Technology; Knowledge Society and Knowledge Policy. GM foods, Nano foods and cloned foods have been the focus of a number of scientific reports and policy advice in ITAS.

[9] See http://www.ethikrat.org/?set_language=en
[10] See http://www.tab-beim-bundestag.de/en/
[11] See http://www.itas.kit.edu/english/

Government Institutes

The German Government has also its own in-house advisory bodies, some of which are focusing on GM food and related issues:

- The Federal Office of Consumer Protection and Food Safety (BVL) is home to the Central Commission for Biological Safety (ZKBS) which assesses applications for biotechnological experiments and commercial operations (in closed systems as part of microbiological production units as well as concerning the deliberate release e.g. of genetically modified plants)[12].
- The central agency for assessing possible health risks for consumers from food, chemicals and other consumer articles is the Bundesinstitut für Risikobewertung (BfR; Federal Institute for Risk Assessment).The institute offers policy advice, participates in national and international agencies and disseminates consumer information. One important component is risk communication and the various forms it can take[13]. The BfR acts as the national Focal Point which coordinates the exchange of scientific information between the European Food Safety Authority (EFSA), the authorities responsible for food and feed safety in Germany and stakeholders from the business community, political circles, the sciences and consumer associations. National Focal Points have been set up in all 27 Member States of the European Union (EU) as interface between the individual Member States and EFSA. In this way, risk assessment activities in the individual Member States are to be coordinated on the European level.

[12] See http://www.bvl.bund.de/EN/Home/homepage_node.html

[13] See http://www.bfr.bund.de/en/home.html