An Evidence Review of Public Attitudes to Emerging Food Technologies

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A report carried out on behalf of the Social Science Research Unit, Food Standards Agency

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1 Introduction

During the last decade there has been intermittent but often intensive attention on new food technologies, particularly on GM food. Other developments have also had a bearing on public opinion in this area, whether or not they were explicitly linked to food at the time. The birth in 1997 of the first animal cloned from an adult somatic cell for example[1] attracted high levels of media attention - as did its early death - and this has undoubtedly had a lasting effect on public opinion of cloning.

Given the Food Standard Agency (FSA)'s focus on protecting consumer interests in relation to food, public opinion towards new food technologies is something it clearly needs to consider. In order to do this however, it needs to be kept abreast of available evidence on this subject.

1.1 Scope of the review

In September 2008, the FSA commissioned Brook Lyndhurst to conduct a review in order to consolidate its knowledge of public[2] opinion on emerging food technologies[3]. In particular, it wanted to better recognise public attitudes and ascertain where the gaps were in overall understanding of these.

The aim of the review was to establish what was known or, more precisely, what data had been publically released about the following:

- what the public's views are on emerging food technologies;
- what views differ depending on the type of technology;
- what shapes the public's views;
- whether different types of people hold different views;
- how views affect behaviour such as food choices;
- how views have changed over time;
- what relevant research is in progress; and
- what the gaps in the research are.

The FSA had already initiated the review process by conducting an in-house exercise to identify the existing information available in its library and by developing a database of sources. Prior to commissioning Brook Lyndhurst, it had identified 170 documents as meeting its inclusion criteria[4].

Brook Lyndhurst was asked to pick up where the FSA had left off. Its role in conducting the review was two-fold:

- in a first instance, to check whether there were any additional sources which had hitherto not been identified;
- then, to synthesize the information in these identified sources.

These two strands were to be complemented by a series of contacts with eminent people in the field to ensure that:

- the research team had indeed uncovered the most relevant material;
- the FSA could be made aware of any unpublished research in progress or in the pipeline.

The overall aim was to make recommendations on any evidence gaps by the end of October 2008, ready for an FSA board meeting in November.

[1] Dolly the sheep
[2] The term 'public' referred to consumers but could also include professional views and those of stakeholders
[3] The technologies mentioned in the tender document were: GM food, novel food processes, food irradiation, nanotechnology, animal cloning, functional foods and synthetic biology (although this was not meant to be an exhaustive list).
[4] Please see Appendix A

1.2 Methodology

The methodology for this compact evidence review entailed four elements.

The initial search for materials

The search element aimed to cover academic, grey, government and commercial sources. It was principally conducted through on-line methods, and in particular through searching the following sites:

- Google scholar (which scans academic journals);
- Referencing in other relevant articles;
- Google (which scans grey, government and commercial sources);
- International Food Information Council (IFIC) website;
- The European Food Information Council (EUFIC) website;
- The Food Policy Institute at Rutgers website;
- The Pew Initiative on Food and Biotechnology website;
- The ESRC genomics networks website;
- The Project on Emerging Nanotechnologies website;
- Commercial research company websites (e.g. Ipsos MORI, Gallup, NatCen, Opinion Leader, BMRB);
- Interested group website (e.g. Friends of the Earth; Greenpeace; Demos);
- International Risk Governance Council website.

A variety of terms were used in the search for additional materials on each technology (a full list of successful terms is included in Appendix A) and, overall, the quantity of materials that the search uncovered was very high. For example, by entering the following terms into Google Scholar, we found:

- "public attitude genetic modification food UK 1999-2008" - 14,400 articles
- "public attitude genetically modified food UK 2008-2008" - 1,050 articles

One of the explicit specifications of the brief was that records should be transparent enough to allow future studies to be added to the review and enable anyone else conducting the review to come to the same conclusions.[5] We therefore took great care to make a record of all sources which met the inclusion criteria. This was done on a spreadsheet split by technology, which included (see Appendix A):

- details of the year of publication;
- the search terms used to find it;
- keywords;
- summary; and
- abstract.

In total, some 419 sources were identified as meeting the inclusion criteria and logged[6].

The prioritisation of materials

Given the constraints of the timetable, the initial search for additional sources as well as the reading and reviewing of these materials could take no longer than four and a half weeks[7]. It was therefore clear from outset that there would have to be process of prioritisation, after which only the most pertinent articles could be reviewed in full.

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[5] Please see: www.gsr.gov.uk/professional_guidance/rea_toolkit/what_is_an_rea/methods_for_reviewing_evidence/full_systematic_review.asp

[6] 200 of which fell under the 'GM and biotechnology' category and only five of which related to synthetic biology - Searches for "synthetic biology public opinion" and "synthetic biology food technologies" for examples yielded no results.

[7] We allocated a total of 33 researcher days for the reviewing element.

In order to facilitate this process, a rating was given to each of the sources identified as meeting the inclusion criteria according to:

1. the quality of the source;
2. the methodology used to conduct primary research;
3. the extent to which the source answered each of the main research questions (i.e. what are the public's views on the technology in question etc);

The research team also made a note of the date of publication, the countries in which any primary research had taken place and any other information which might influence whether or not a source should be reviewed (see Appendix A). On this basis, the sources were then classed as high, medium or low priority - with a total of 92 sources falling under the initial heading.

The full review

In order to deal with the amount of information generated through the full review of the prioritised sources, a new spreadsheet was drawn up which included headings for each of the key questions the project sought to answer[8] as well as the opportunity to record any additional comments.

Any information provided by the source material was entered under the relevant heading, thus providing a strong basis for subsequent analysis of the data collected (see Appendix A).

As the research team conducted the full review and followed up pertinent citations, a handful of new sources were added to initial prioritisation list. By the end of the process, 105 articles had been read and fully documented.

Contact with eminent people in the field

As already outlined, the purpose of our contacts with eminent people was two fold - to ensure we had uncovered the most relevant material and to be made aware of any research that was about to be published or was in the pipeline.

We therefore contacted a mix of academics, people working within interested organisations both within government (e.g. the Department of Health, the Environment Agency) and outside it (e.g. the Royal Society, Demos) and organisations who might be conducting primary research in the field (e.g. Ipsos MORI, BMRB).

In total 26 organisations were contacted[9] and we received responses either over the phone or through e-mail – from 16. A flavour of successful contacts is included in Appendix A.

1.3 This Document

In section 2 we present 'Overall findings' that have emerged from the review. In section 3 we present detailed evidence for each the novel food technologies covered by the review; and in section 4 we present our conclusions and recommendations.

Throughout the main body of the document we provide two kinds of reference. References of the form "Note 1" refer to the provision of more detailed information on the point made in the main text. Notes are presented in section 5, for each of the main elements of sections 2 and 3.

The second kind of reference – "Chen and Li, 2007" – refers to the specific source of the information referred to. These references are provided in the bibliography, presented in section 6.

[8] i.e. what the public's views were of the technology in question, what shaped those views and so forth
[9] In most cases, numerous times

Appendix A, at the end of the document, details the methodology used in conducting the review; while an executive summary of the report is separately presented.

2 Overall findings[10]

2.1 Introduction: a comment on the nature of the evidence

The quantity and quality of evidence available across the different technologies included in this review varies widely. The largest body of data by a long way relates to public attitudes to GM; however, there was very limited evidence available for some of the other technologies. For example, our search revealed just two sources relevant to public attitudes to synthetic biology in general, and including 'food' in the search terms drew a blank. Consequently, some chapters, particularly those on synthetic biology and nanotechnologies, draw on a number of sources that, although not directly related to food, shed some light on public attitudes to such novel technologies and how this might translate into attitudes towards food applications.

The other technologies lie somewhere in the middle of these two extremes. For some (such as irradiation), there is plentiful data available for the USA, but limited research conducted in the UK. For others, such as nanotechnologies (and, to a lesser extent, animal cloning), most research does not focus on food applications. Research about the technologies that are inescapably about food (functional foods and novel food processes) are often focused on particular products in particular locations (for example, the Brazilian public's reaction to functional orange juice), which makes it difficult to draw general conclusions.

The quality of data also varies. The shortlisting criteria used for the final selection of sources included an evaluation of methodologies (see section 1.2 and appendix A for full details). However, for some of the technologies, in order to go some way to answering the research questions, we included some evidence that did not score highly in the methodology evaluation (for example, surveys that used non-representative samples). These instances are clearly marked in the text.

It is also essential to interpret findings (of the primary research and of this review) in the context of the inherent limitations of the methodologies used in the primary research.

Firstly, much of the evidence is based on one-off surveys, which can only give a snapshot of a small sample of a population at a particular time. Taken together, many such surveys can begin to give rise to top line conclusions, but even these must be treated with caution since most surveys use different sampling methodologies and questions and are therefore not directly comparable. Even repeated surveys often use different questions and, in situations of high uncertainty and limited understanding (conditions that apply to most novel food technologies), slight changes to question wording can lead to disproportionate changes in outcomes. In uncertain situations, views are also highly affected by the external context, so media attention on a technology around the time of a survey can also have disproportionate effects. As we shall see, views can also change across individual and group situations.

Secondly, it became clear as we reviewed the evidence that novel food technologies are generally not a top of mind concern for most people. When presented with issues that they rarely think about, research participants tend to give their emotional response to their first impression of the subject, rather than a considered opinion. Asking people to agree or disagree with a set of statements about a technology may not always result in an accurate reflection of views.

No social research takes place in a vacuum, and it is impossible to completely exclude research effects. However, with an issue as complex as novel food technologies, research design is an even more important variable.

[10] Please note that much of this section is drawn from the chapters on individual technologies, and references that are contained in those chapters are not repeated here. Please see individual chapters for full details and references.

2.2 What are the public's views?

Public attitudes are unsupportive

The overall tone of public attitudes towards novel food technologies is one of wariness, unease, uncertainty, and sometimes outright negativity. As Young (2003) argued, the public has always been suspicious of new food technologies – tinned food was resisted for decades after its introduction. This seems to be partly explained by the fact that food is not simply thought of in functional terms; rather, it is part of a much wider social and psychological setting which includes, among the multitude of variables, attitudes to health, the environment, and science, as well as deep seated values and fundamental world outlook, not to mention personal and familial habitual behaviours.

It is perhaps for this reason that the public disagrees so strongly with the idea that some technologies, such as GM, are simply another food production process (DTI, 2003). It also may go some way to explaining why food applications are found to be the least acceptable of all applications of technologies such as GM, animal cloning and nanotechnologies (other applications include medical and industrial).

The same research that demonstrates generally unsupportive attitudes also indicates that novel food technologies are not a top of mind concern for the majority of people, and initial interest in the subject matter is often low. However, this is not to say that the public is not interested in the debate; once prompted, the majority of people take a view.

An undecided majority

A common theme across the different technologies is the existence of minorities at each end of the scale with strongly positive or negative opinions, and a majority who are undecided or felt that they did not know enough to form a view. When the views of this undecided majority are explored, however, most evidence suggests that they tend to be moderately negative, although some studies find a more or less equal divide.

Levels of awareness are varied

Levels of awareness of novel food technologies are generally low. For example, the majority of UK consumers are not familiar with the term 'nanotechnology' (so it is fair to assume that an even lower number would be aware of food applications), and in the USA, consumers are generally unaware that they are eating GM food, despite its widespread availability. Anecdotal evidence suggests that the concept (if not the products) of functional foods is largely unknown, as is synthetic biology and its applications.

Notable exceptions to this are animal cloning and GM. 81% of UK respondents to the Eurobarometer survey in 2008 had heard of animal cloning and 94% of UK respondents to another international survey had heard of GM (Blaine et al, 2002). It is likely that this high level of awareness is due to a combination of media attention on the debate, high profile scientific developments such as Dolly the sheep and, in the case of cloning, the frequent appearance of the technology in popular culture (see section 3.2, Cloning).

Understanding is limited

Understanding of the science of novel food technologies is low. Even for animal cloning, where levels of awareness are high relative to the other technologies, understanding generally does not extend to the technical or scientific aspects of the process. Similarly, the majority of people say that they are not confident enough in their own knowledge to explain most technologies to another person. Very few people are able to offer unprompted definitions of the technologies, although a higher proportion is able to select the correct definition from a list (for example, for cloning and GM).

Views in different countries

Attitudes in the USA seem to be, in general, more positive than in Europe across most of the technologies we reviewed. Several reasons are put forward to explain this, including Americans' more positive attitude to science and technology and their higher levels of trust in their regulatory authorities. Consumers in Asian (Chen and Li, 2007) and developing countries (Hoban, 2004) also tend to have more positive attitudes to novel food technologies, in particular GM, indicating greater perceived benefits in these locations. Within the EU, attitudes can differ

substantially; for example, UK respondents to the Eurobarometer (2008) were significantly less likely to think that animal cloning is morally wrong than the EU average.

2.3 Do views differ depending on the type of technology?

The technology that elicits the most positive attitudes is functional foods. The evidence suggests that the most important reasons for this are the clear consumer benefits (perhaps due to advertising) and low perceived risk; and the process involved (for example, adding vitamins) is not unfamiliar or unimaginable to consumers (Roneltap et al, 2007). A survey in Canada found functional foods to be on a par with other established food processing techniques, in contrast to food irradiation and GM, which were seen as high risk, low benefit technologies (Henson et al, 2007).

The technologies that give rise to the most concerns are GM and animal cloning, closely followed by synthetic biology (although no evidence is available specifically about food) and nanotechnologies that would be ingested (nano-inside, rather than nanotechnologies used in packaging etc – nano-outside (Siegrist et al, 2008)). These technologies are particularly subject to moral and ethical concerns, including fears about irreversible changes to the natural order, and even 'playing god'. They are also the technologies that represent the greatest departure from what the public perceives to be 'traditional' and 'natural' food; research shows that this increases feelings of loss of control and deepens suspicion of those developing the technologies.

Food irradiation also elicits responses of wariness. It is also an area of low understanding and misassumptions – one in three people stated that they would consider an 'irradiated food' label to be a warning and so try to avoid the product (He et al, 2005b).

There are very few studies that compare different novel food technologies to each other, with the exception of GM, which is often used as a benchmark to measure acceptance of other technologies (for example, Henson et al, 2007 - irradiation; Priest, 2006 - nanotechnologies). One of the few studies about novel food technologies in general suggested that US consumers are less concerned about many novel food processing technologies than about GM food and irradiation (Cardello et al., 2007) [Note 1], a general finding supported by the overall evidence.

2.4 What shapes the public's views?

The main determinant in shaping public attitudes emerges from the literature as a personal evaluation of *perceived risks and benefits*. Perceived risks and benefits are based on a complex array of variables, of which knowledge of the technology is only one (and a minor one at that). Reactions to the idea of unfamiliar technologies tend to be based on 'emotional heuristics' (Lee et al, 2005), and this kind of *affective response* not only shapes perceived risks and benefits, but mediates the effects of new information about a technology. Emotional responses are anchored in deep seated cultural values and *general attitudes*, which become proportionately more important in situations of uncertainty and low understanding. Underlying all of this is *trust* – social trust, trust in science, government, and the food industry – which feeds into the formation of general attitudes, mediates information assimilation, and has a direct effect on attitudes to specific technologies.

Below, we consider each of these main themes in turn; however, it should be noted that such linear treatment does not fully capture the complex and interdependent relationship between them.

Risk-benefit perceptions

Perceived risks of all the technologies are well documented, and tend to centre on health risks to self and family, and environmental risks in the case of the biotechnologies. There is evidence that health risks carry more weight than environmental risks; for example, people are more accepting of GM crops than GM foods (Gaskell et al, 2000), and health risks are also stated to be more important than beliefs about science and/or religion by a majority in the USA (Mellman Group, 2006[11]). Uncertainty is a key driver of concern, especially with regard to potential long term and unintended consequences.

[11] Review of Pew Initiative on Food and Biotechnology research

Although research participants are able to identify long lists of risks, most struggle to identify benefits unless prompted. A key finding is that benefits must be tangible and direct in order to figure in consumers' risk-benefit evaluations (Hossain and Onyango, 2004; Costa-Font et al, 2008; Seigrist, in press); for example, direct health benefits are the most frequently cited potential benefit that would increase acceptance (e.g. Verbeke, 2005).

Risks and benefits are often negatively correlated with each other (higher perceived risk is associated with lower perceived benefit), but are subject to different weightings. The evidence regarding the relative values of risks and benefits is mixed, which suggests that perceived risks and benefits carry different values depending on an individual's pre-existing cognitive predispositions.

The main benefits identified by research participants centre on health and environmental benefits, as well as considerations about positive impacts on developing countries. Supporters of some of the biotechnologies also argue that countries who do not push technological development will be left behind. However, overall, a lack of perceived benefits leads the majority of people to question the need for and usefulness of novel food technologies, and increases suspicions that the main motive for developing new technologies is profit.

The evidence suggests that the majority of people are moderately risk tolerant, despite their stated caution about perceived potential risks. An important finding, however, is that consumers are willing to accept higher levels of voluntary risk, but risks that seem out of their control are much less acceptable (Ronteltap et al, 2007; Cardello, 2003). The perceived control that consumers feel over what they purchase and eat is a crucial driver of attitudes (Saba and Vassalla, 2002; Ronteltap et al, 2007). One direct consequence of this is high levels of support in all locations for tighter (or perhaps more obvious) regulation and clear labelling systems.

General attitudes

Despite stating that they know little or nothing about most technologies, when asked, the majority of people do take a view one way or the other, even if those views are not strongly felt. Since these views are not based solely on knowledge of the technology, this suggests that people rely on pre-existing knowledge and values to form their judgement.

This is supported by the many studies that find that general attitudes are the most important drivers of attitudes towards novel food technologies. Several find general attitude to science and technology to be the most important explanatory factor in public attitudes, and others find significant effects of cultural values or world outlook; for example, the studies that measure the egalitarianism vs hierarchism and individualism vs communitarianism of participants.

Other general attitudes that are found to be important in shaping views are attitudes towards health and nutrition; the environment and conservation; and personal norms around social and economic equity. The latter is demonstrated by people's view that only the wealthy will benefit from novel food technologies (or have the resources to avoid them), as well as the widespread concern about the effects on developing countries of the agro-biotechnologies. These concerns also overlap with moral and ethical worries in relation to the biotechnologies, principally about making irreversible changes to nature and 'playing god' (Hallman, 2006).

Attitudes to food in general are also important, and individuals tend to strive for consistency in their views (in order to avoid cognitive dissonance – see Festinger, 1957): for example, those who have a negative view about one novel food process tended to also have negative views about others (e.g. Cardello, 2003).

The process of attitude formation in accordance with pre-existing, general attitudes and values is known as a 'top down' process, in contrast to 'bottom up' attitude formation based on specific knowledge of a topic. In general, both processes occur simultaneously; however, in the case of novel food technologies, where bottom up knowledge is limited, top down processes are found to be more important in shaping public attitudes (e.g. Grunert et al, 2004).

Emotions

Limited bottom up knowledge and reliance on pre-existing values combine to cause an affective or emotional response from the majority of people in research situations. Most studies find that

novel food technologies are not on the top of people's agendas, and so responses in survey situations tend to be reactions to a first impression of the idea of a technology.

It seems that individuals are predisposed to make certain associations with novel food technologies, and for a significant proportion, these are negative; for example, one in three EU citizens agreed with menacing images of GM suggested to them (for example, "By eating genetically modified fruit, a person's genes could also become modified"), indicating that many people are inclined to assume the worst (Gallup/Eurobarometer, 2008). Underlining the complex psychological relationship people have with food, several studies find that the language of novel food technologies can deepen negative associations; for example, the terms 'irradiation' and 'cloning' are often found to cause discomfort.

An important association that drives attitudes towards the products made with novel food technologies is the perceived 'naturalness' of both the technology or process and the resulting product. For example, consumers are much more likely to accept 'natural' combinations in functional food, such as milk fortified with calcium, than seemingly 'artificial' combinations, perhaps due to the perceived veracity of the health claims (Poulsen, 1999). [Note 2]

Consumers are also more comfortable with applying novel technologies to plant based products than animal based products; for example, evidence suggests that irradiation of fruit is more acceptable than irradiation of meat, and it is well documented that GM food falls into a hierarchy of acceptability, with application to the 'higher' (larger) animals being least acceptable and applications involving micro-organisms causing least concern. Additionally, it seems that people are more likely to accept some technologies such as GM in food that they didn't expect to be healthy anyway; for example, research in the USA showed that GM ingredients were most acceptable in snack foods (e.g. Cormick, 2007). This perhaps hints at a perception or association that food produced using novel technologies is less healthy than other foods.

Knowledge and the effects of information

The evidence regarding the effects of new knowledge is mixed, with some studies finding that new information has no significant effect, and others finding positive or negative effects of new information. For example, a field experiment by Hayes et al (2002) demonstrated the positive effects of positive information about irradiation on both attitudes and behaviour. In contrast, qualitative work by the FSA/COI (2008) found that views on animal cloning were relatively neutral at the beginning of the research process, but as people found out more, views became much more polarised, with the majority becoming more concerned.

This indicates that, in reality, the effects of new information can go either way. Unsurprisingly, positive information tends to have a positive effect on views, whereas negative information generally has a negative effect. The evidence also suggests that negative information carries more weight than positive information; for example, in the field experiment mentioned above, the group who received both positive and negative information, resulting attitudes and behaviour were similar to those who had only received the negative information (Hayes et al, 2002).

However, although there seems to be a rough correlation between hearing positive information and forming a positive attitude, the literature makes it clear that the relationship between information and attitudes is not simple, but is mediated by a variety of other factors. For example, pre-existing knowledge, values and associations lead to biased assimilation of new information, with information that does not fit with existing cognitive conditions being rejected. Similarly, people are more likely to follow the viewpoint of a source of information with a similar world outlook (or cultural values) to their own. This explains how the views of people who hear the same mix of information can become polarised, and suggests that positive information will have a greater effect on those who already have a positive attitude, whereas those with pre-existing negative affect are less likely to assimilate positive information.

A final important point is that pre-existing knowledge of a technology can often be an indicator of support, since those who are most likely to be interested in finding out about a technology tend to be predisposed to support it (Kahan et al, 2007; Priest, 2005). This means that correlations between greater (pre-existing) knowledge and a more positive attitude may be misleading, since they may be applicable only to a non-representative subset of the population.

Trust

Another important factor that mediates the assimilation of new information is trust in the information source, and this is found in some research to be more important than the accuracy of the information itself (Bruhn, 2008). In general, higher levels of social trust are associated with more positive attitudes to novel technologies overall, including novel food technologies.

In most locations, the media, government and industry tend to be the least trusted sources of information. People are particularly sceptical about the motives of 'big business', suspecting that the driver is profit, rather than consumer benefit. This is even the case for technologies where consumers perceive clearer benefits, such as functional foods, with consumers expressing a desire for reassurance that the health claims made on the labels of functional foods are true, and not just another means of increasing company profits.

The most trusted sources of information varies across location. There is some evidence that, in contrast to most other locations, the media is the preferred source of information about novel food technologies for Asian consumers (Chen and Li, 2007). Several studies indicate that consumers in the USA have higher levels of trust in the national regulator than European consumers, whereas Europeans put more faith in 'activists' such as consumer and environmental groups that they perceive to be independent from the special interests of government and business.

It is interesting to note the interaction of cultural values in this area too: for example, one study found that Turkish consumers would be more likely to have a positive attitude towards a novel food technology if trusted food companies or brands were to use that technology, whereas in the UK, it seems that companies would seriously risk their reputation by incorporating new technologies into their lines (Gunes and Tekin, 2006; Deliza et al, 2003).

Many people express a mistrust of science and/or scientists, on the grounds that they may not know when to stop and may not have consumer best interest in mind. However, a contradiction often arises: on one hand, consumers state that they expect and prefer to rely on experts (scientists and regulators) to make decisions for them, but on the other hand they state that they do not trust these same experts. Many cite previous crises, both about food (e.g. BSE) and wider issues (e.g. asbestos and nuclear power) as evidence that the government does not know enough to ensure safety and that science can sometimes get it wrong. It is perhaps for these reasons that several studies find that one of the most trusted source of information about novel food technologies are friends, family, or other sources with some personal significance (Mellman Group, 2006; DTI, 2003).

Finally, another trusted source of information seems to be health professionals, such as doctors and nutritionists (e.g. IFIC, 2002). Trust in these sources is likely to be driven by the perception that these actors are independent from special interests and have the consumer's best interests at heart.

2.5 Do different types of people hold different views?

Many research studies test hypotheses about the effects of sociodemographic characteristics on attitudes. The most consistent finding in this area is that women are more concerned, less positive, and likely to perceive fewer benefits of novel food technologies than men. The one exception in the technologies covered in this review is functional foods, where women are more likely to be positive and more likely to have bought functional foods. It is unclear from the literature why this should be the case; however, possible explanations include the greater value put on health benefits by women (e.g. Miles et al, 2004), and the fact that much advertising of functional foods (for example, yoghurts and cereals) is aimed at women.

Other than the persistent gender gap, evidence about the effects of demographic characteristics is mixed. Some evidence suggests that older people are more concerned about novel food technologies, although functional foods are again an exception to this rule.

Different studies find different and contradictory effects concerning socio-economic group, income and education levels, and no patterns emerge from the evidence overall. The fact that the differences found do not follow an overall pattern suggests that sociodemographics are not the most important explanatory factor. One study that found a significant relationship between socio-

economic group and attitude in a bivariate analysis of the survey data found that the relationship disappeared in a multivariate analysis that included values and beliefs (Verbeke, 2005). This indicates that sociodemographic characteristics are a less important explanatory variable than values, beliefs and attitudes.

This conclusion is drawn by several researchers (e.g. Verbeke, 2006; Henson et al, 2001), and is supported by various findings from other studies. For example, amongst those with strong pro-environmental attitudes, the gender gap disappears (Frewer et al, 1998, cited in Costa-Font et al, 2008). Another example is that, although older people are likely to be more concerned across the board about novel food technologies, they are more likely than other age groups to have a positive attitude towards nanotechnologies used in food packaging. Given the likelihood of older people having deeply negative attitudes towards food waste (Defra, 2008), it may be that this waste prevention value explains more of their positive attitude to nano-packaging than their age.

The fact that values, general attitudes, beliefs and experience are better predictors of attitudes towards novel food technologies than socio-demographic characteristics is demonstrated by the development of alternative population segmentations based on attitudes and behaviours towards food, rather than socio-demographics [NOTE 3]. Overall, the evidence suggests that it is too simplistic to assume that there is any such thing as public attitudes to novel food technologies: there is not a single 'public', and attitudes depend not only on evaluations of the technologies themselves, but can change depending on the application of that technology and the product it is applied to.

2.6 How do views affect food behaviour and choices?

The evidence suggests that intention to purchase is directly related to attitude – those with a positive attitude state that they are more likely to purchase and eat food produced with emerging technologies, and those with negative attitudes are less likely to purchase and eat such products. Data exist in some areas to support these stated intentions; for example, in the area of functional foods, those with more positive attitudes were more likely to have already purchased functional foods, and were more likely to have purchased a wider range of functional foods (Urala and Lahteemaki, 2007).

With regard to other novel food technologies, especially those that are not widely available, stated intentions are an unreliable guide to actual behaviour. This may be partly explained by the idealised view of their own shopping habits that consumers have in terms of buying healthy, green, or unprocessed foods (Cormick, 2007). It may also be explained by the fact that, in a survey situation, respondents often answer as citizens, rather than consumers, which means that the economic driver of price is absent from their stated preferences (Gaskell et al, 2006). For the less widely available technologies, there is little data to confirm (or refute) claimed intentions, except a small body of experimental field research (e.g. Hayes et al, 2002; Hashim et al, 2001).

In survey situations, consumers with negative attitudes towards novel food technologies state that lower cost would not be a strong enough benefit to convince them to buy products and, in experimental settings, people are often found to be willing to pay a premium to avoid products involving GM, irradiation and cloning. Research participants also state that increased shelf life is an insufficient benefit to persuade them to purchase (Costa-Font et al, 2008).

In reality, various factors are taken into account in purchasing decisions other than simply an evaluation of the processing or production technique, including price, taste and convenience. These variables often overlap; for example, expectation of enjoyment as well as evaluation of taste have been shown to be affected by attitude towards the process or technology involved in production (Seigrist, in press; Cardello, 2003). In addition to this, there is some evidence that shopping habits tend to be habitual, which means there may be little scope for attitudes to influence purchasing decisions once consumers have made up their mind about their preferences (Frewer, personal communication). Following this line of enquiry, however, was outside the scope of this research.

Consumers use price as a signal of quality (although they do so heterogeneously among products) (Costa-Font et al, 2008), and this also interacts with attitudes towards food technologies. A clear illustration of this is that those with positive or neutral views towards a novel food technology tend to make their decisions based on perceived utility of the product, including price, whereas those with strongly negative views tend to make their decisions based on values or ideology, which dominate cost considerations (e.g. Costa-Font et al, 2008; Cox et al, 2007). This finding is supported by several studies investigating willingness to pay for some of the most controversial technologies (principally GM), which find that even supporters of the technology would require a discount to buy a full basket of GM goods.

2.7 How have views changed over time?

The available evidence does not allow firm conclusions to be drawn about how views have changed over time: there is a lack of longitudinal and timeseries data and, as we have seen, the variations in methodologies used across the various studies mean it is largely non-comparable.

There are, however, a number of general comments to be made. Firstly, public attitudes are generally ambivalent, and although there have been some cycles of volatility, the changes have occurred within parameters that mean the majority of people have remained neutral, undecided, and slightly wary during the time period covered by this review (1999 – 2008).

Secondly, short term changes over time in awareness and attitudes seem to be related to media attention on the technologies themselves, as well as wider food issues. In general, media reporting of these issues tends to be somewhat negative or to concentrate on economic and scientific merits which, as we have seen, do not appear in utilitarian evaluations since they are not direct and tangible personal benefits. Despite consumers (at least in the UK) viewing the media with "robust scepticism", it does seem to be an important source of information about these issues and is therefore significant in shaping public attitudes.

Thirdly, as a general rule, people are most suspicious of the least familiar technologies and, in both survey and field research, familiarity is linked to increased levels of acceptability (e.g. Cardello et al, 2007). One illustration of this is the case of GM: in locations where GM food is widely available, attitudes tend to be more positive (Chen and Li, 2007). Finding out that GM is widely available decreases concerns about safety, and the availability of GM overseas is an important argument used by supporters of GM. It seems that, where GM food is available, the benefits (for example, lower prices) are more salient than the risks (which are assumed to be minimal if GM has been 'allowed'). In contrast, where GM is less common and the public debate is ongoing (e.g. in the UK), the benefits are less obvious and the risks of the unknown loom large.

2.8 What research is in the pipeline?

Our contact with academics working on public attitudes to novel food technologies revealed that many have outstanding applications for funding through the Seventh Framework Programme at the European Commission (FP7)[12]. Within FP7, both the 'nanosciences' and 'science and society' calls are relevant to the FSA's work.

GM

Public attitudes to GM is a fast moving and active research area with new material appearing all the time. Some upcoming work includes:

- The EU funding a large body of work on the perceptions of GM animals. This work is due to start next year and will be coordinated by Prof. Lynn Frewer at Wageningen University. Among others, it will implicate the Institute for Food Research.

- The first longitudinal study on perceptions of GM at the Institute for Environmental Decisions in Zurich. The study (which is limited to the Swiss population and is taking place over three

[12] This is the EC's main instrument for funding research in Europe between 2007 and 2013. It has a €3.5 billion budget for 'nanosciences, nanotechnologies, materials and new production technologies', and a €280 million 'science and society' budget, which aims to bridge the gap between science professionals and those without a formal science education.

years) will use implicit association testing to measure perceptions of GM through looking at acceptance of field release experiments (including measurement of peoples' knowledge of GM and attitudes towards food and medical applications).

Cloning
FP7 awards are still pending, but notwithstanding this:

- A project at Ghent University is working on consumer acceptance of biotechnology and cloning in animal production.

Nanotechnologies
Nanotechnologies are an extremely active area of research which will be covered under FP7 but awards are still pending:

- Work is being done at Wageningen, Cardiff and Lancaster universities on attitudinal differences towards nanotechnologies and the psychological underpinning of these differences.

- In particular, Prof. Lynn Frewer at Wageningen is currently conducting a nationally representative study of the UK public to look at how risks and benefits are weighed up.

- The STEP project (Sensitive Technologies and European Public Ethics)[13], coordinated by the London School of Economics, will examine public understanding and attitudes towards developments in modern biotechnology across European member states. This will include nanotechnologies.

- Experimental work on influencing peoples' perceptions of nanotechnologies is being undertaken at the Institute for Environmental Decisions in Zurich.

Irradiation
- Prof. Rudy Nayga is currently conducting work on consumer attitudes to irradiation in the US, although we do not have precise details of this project.

Functional foods
- Prof. Wim Verbeke at Ghent University has been looking at consumer acceptance of nutritional enhancement in pork and beef products in his work (see above).

Novel food processes
We are not aware of any current work.

Synthetic biology
Work is being conducted under the EC's SYNBIOSAFE project through the EC-FP6 programme but does not seem to directly cover food applications.

[13] http://www.stepe.eu/ - The purpose of the STEPE project is to investigate broader public concerns in relation to modern biotechnology. Those involved in the project see consideration of these concerns as crucial for sustainable technology development.

3 Detailed findings

3.1 Genetically modified foods

Chapter 3.1 summary | **Genetically modified foods**

- **GM[14] is not a front of mind concern for most people**
- **The majority of UK consumers perceive GM to be of medium risk, but due to a lack of perceived benefits, the risks still outweigh the benefits for most**
- **Attitudes to GM are embedded in a complex set of psychological, social, political and ethical drivers**
- **Views are based on general attitudes and affective responses, rather than information about GM itself**
- **Government and industry are the least trusted sources of information**

GM food is the most researched technology covered by this review, and our search uncovered the largest number of pertinent studies in this area. This meant that the likelihood of finding data based on robust methodologies was higher for this technology than for any other.

The individual studies reviewed here were judged to be based on clear and reasoned methodologies. As a body of evidence, however, the research is somewhat sporadic, with most data coming from one off surveys that give only snapshots in time. The Eurobarometer is the most comprehensive survey giving an idea of changes over time and we make several references to its results. We have also included qualitative research that aims to explore the underlying drivers of attitudes, notably Costa-Font et al (2008) who use a technique known as laddering to reveal fundamental values on which attitudes are based; the large scale and multi-technique GM Nation study conducted in the UK (DTI, 2003); and focus group research convened by the FSA (2003).

What are the public's attitudes to GM foods?

Awareness and understanding is low

Unprompted awareness of genetically modified food (GM) is low, and GM is not a front of mind concern for the majority of people [Note 1]. Research by the Food Standards Agency [FSA] (2003)[15] suggests that UK consumers do not have a strong initial interest in the subject: only 5% of those surveyed expressed unprompted concern about GM food, and even within a discussion of food safety the subject rarely arose. However, the vast majority of UK consumers do recognise the term 'GM' and know what it stands for (Blaine et al, 2002[16]; FSA, 2003). In the USA, two surveys asked an open question about information people would like to see on food packaging and just 2% of respondents mentioned GM (Hoban, 2004)[17] [Note 2].

Knowledge and understanding of the subject matter is also limited. The majority of people in the UK, Australia and the USA give incorrect explanations or state that they do not know enough to explain GM to another person (FSA, 2003; Mellman Group, 2006[18]; Cormick, 2007[19]; IGD, 2008[20]).

An undecided but uneasy majority

The most common response to questions about GM food is one of uncertainty and unease (DTI, 2003[21]; IGD, 2008; FSA, 2003; Gaskell et al, 2006[22]; Environics International, 2000[23]; Traill et al,

[14] "GM" is used throughout this report to refer to both the general field of genetic modification, as well as its specific application with respect to food. Where the distinction is relevant, a note appears in the text.
[15] n= 3,000 (over 3 years)
[16] n= 500; survey carried out in 1999
[17] No details of sample sizes provided
[18] No details of sample sizes provided
[19] n= 1,067, representative sample of the Australian population
[20] n= 5,967
[21] Public consultation with approximately 30,000 participants
22 Eurobarometer. n= 25,000 (approximately 1,000 in each EU Member State)
23 n= 35,000 in 35 countries. Cited in Hoban (2004); about biotechnology in general

2004[24]). The Eurobarometer survey showed that in 2006 half (51%) of survey respondents across the EU did not have a decided view on GM food. Other surveys found equal splits between those who are concerned and not concerned (Cormick, 2007 - Australia); COI, 2007 - UK). Even in the USA, where public attitudes are generally more positive to GM than in Europe (Cormick, 2007; Hoban, 2004; Mellman Group, 2006; Gaskell et al, 2006), only 27% of people actively supported GM (Mellman Group, 2006).

Among those who do have a decided opinion in European countries, attitudes tend to be negative. In the EU as a whole, 25% of those with a firm opinion are outright supporters and 58% are outright rejecters (Gaskell et al, 2006), and a majority across the EU thinks that GM food "should not be encouraged." A study by Saba and Vassalla (2002)[25] illustrates this point. They found that only 6% of Italians were strongly positive about the idea of eating genetically modified tomatoes, whereas 39% felt strongly negative.

Attitudes in the UK were invariably found to be unenthusiastic and, as elsewhere, undecided. In a study conducted by the IGD (2008) 52% of respondents were found to neither support nor oppose GM, or to not know, 15% to strongly oppose it and just 3% to be strongly in favour of it. Poortinga and Pidgeon (2004)[26] also reported that over half the population claimed to be unsure of whether GM should be promoted or opposed and the DTI's (2003) *GM Nation?*, based on a range of qualitative research studies across the UK, reported a mood of "passivity, anxiety, suspicion and fatalism." Another study reported that 54% of Britons opposed biotechnology in food and agriculture (Mika, 2005).

In keeping with this overall sentiment, there is little support for the early commercialisation of GM crops and GM food in the UK and Europe; the vast majority (85% in the UK) think that more testing is required (Rigby et al, 2004[27]; DTI, 2003; FSA, 2003) and 41% in a UK survey by COI (2007)[28] spontaneously cited "too many unknowns" as a major concern. A quarter think that GM testing should be completely stopped (Rigby et al, 2004) [Note 3].

What shapes the public's views?

Personal attitudes are formed by a complex decision making process and are shaped by a number of variables. Costa-Font et al (2008) identified three interconnected axes of decision making around GM food:

- perceived risks and benefits;
- personal values and attributes; and
- knowledge of the topic.

Perceived risks and benefits

Weighing up perceived risks and benefits is an important part of the attitude forming process, and much research focuses on this (see, for example, Traill et al, 2004; Costa-Font et al, 2008; Gaskell et al, 2006; Rimal et al, 2005[29]; Chen and Li, 2007[30]). Common themes emerge from studies conducted in different parts of the world and using different methodologies; the most important are listed in the table below.

Perceived risks and concerns about GM food technologies
Health risks to self and family
Risk of contamination of non-GM plants and organisms and consequent **loss of freedom of choice/loss of traditional food.**
Loss of control: scientists and society may no know when to stop. Once GM is released there may be **"no turning back."** Concerns over governments dictating public choice.
Erring on the side of caution: no major technological change should be introduced until its **long term effects on both human and environmental health** are known

[24] n=372 in 5 locations (UK, France and USA)
[25] n= 1000, randomly selected from consumer panel
[26] A national representative quota sample of 1,363 people over 15 years old; face to face interviews
[27] Literature review
[28] n = 2,037, representative sample of the UK population
[29] n = 2,568 from market research panel; online survey
[30] n = 564; stratified sample

Why? There is no need for GM crops
Environmental risk: threat to native wildlife and the balance of nature; over time GM crops may need more pesticides, not less, because of the development of resistant "superbugs" and "superweeds"
Who benefits? The risk of concentrating our food supply in the hands of multi-national companies whose objectives are profit and power, not public wellbeing. Concerns over the 'industrialisation' of food.
Non-material values: the human species has no right to use GM technology to dominate and alter the course of nature and make irreversible changes in the world environment for future generations.
Risks to developing countries: e.g. crop performance not proven; farmers have to buy new seeds every year because seeds are modified to contain blockers…
Perceived benefits of GM food technologies
GM foods are **safe and well tested** – the USA is often cited; opposition seen as 'scaremongering'
The logical conclusion of **caution** is no progress and technological advances at all
Environmental benefits: reduced pesticide and fossil fuel use
Benefits to developing countries: increased yields, reduced crops, drought and disease resistant crops
The right to choose: it is wrong to deny people the benefits of scientific progress
GM is simply a **more precise application of techniques such as selective breeding**
GM will help our country **compete**; without it we will be left behind

Sources: FSA, 2003; DTI, 2003; Cormick, 2007; Traill et al, 2004; Mellman Group, 2006

In studies designed to measure levels of risk tolerance, the majority of people normally fall into a medium risk tolerant category (Blaine et al, 2002[31]; Gaskell et al, 2006; Traill et al, 2004). In general, risks and benefits are thought to be negatively, though not perfectly, correlated (Costa-Font et al, 2008). Several studies find that consumers are more certain of the risks of GM than the benefits, and that risks have a stronger influence on overall attitudes (e.g. Rimal et al, 2005; Gaskell et al, 2006). However, evidence is mixed, and some studies indicate that benefits have more impact on choice (see Costa-Font et al, 2008).

One of the clearest illustrations of the interaction of risk/benefit perceptions are the public's attitudes to different applications of the same technology. For example, the Eurobarometer (2006) shows that EU consumers have an overall positive view of medical applications of GM technology: despite viewing it as risky, they are strongly aware of the potential benefits, which leads to an overall evaluation that medical applications are morally acceptable and should be encouraged. In comparison, uncertainty about the benefits and usefulness of food applications mean that, for the majority, the risks outweigh the benefits (Gaskell et al, 2006; Blaine et al, 2002) [Note 3].

Wider issues

Risk and benefit perceptions are important in shaping public attitudes to emerging technologies. However, Table 1 demonstrates that attitudes to GM food are not based simply on an evaluation of the products themselves, but are embedded in a much wider range of social and political values. This is likely to partly explain why people attack the idea of GM being simply another processing method (DTI, 2003).

The complex set of values and attitudes in which perceptions of GM sit includes general attitudes to health and nutrition (Chen and Li, 2007; Cormick, 2007; Rimal, 2005), to the environment and to social and economic equity (e.g. Poortinga and Pidgeon, 2004; Costa-Font et al, 2008).

General attitudes to science and technology are found by several studies to be the strongest predictor of attitudes to GM food (Grunert et al, 2004[32]; Traill et al, 2004; Cormick, 2007; Chen and Li, 2007; Gaskell et al, 2006); Traill et al (2004) hypothesise that the more positive attitude of Americans toward science and technology explains more positive public opinion of GM foods compared to Europeans.

[31] Literature review
[32] Qualitative study involving 1,200 participants

Utility vs ideology

It has been suggested that, whereas the undecided majority base their attitudes mostly on perceived risks and benefits of GM food, those people at each end of the spectrum who are strong supporters or rejecters of GM tend to rely less on perceived utility and more on 'subjective' knowledge, or personal values and ideologies (Costa-Font et al, 2008; Cormick, 2007). For example, pro-environmental philosophies are found to be significant drivers of a rejection of GM (Rimal et al, 2005; Cormick, 2007).

The importance of moral concerns is highlighted by many studies, especially in the USA, where ethical concerns based in religious faith are a common barrier to acceptability of biotechnology (although many studies find this is more pronounced in the case of cloning - Mellman Group, 2006; Sosin and Richards, 2005[33]). However, in other locations, moral concerns, for example about making irreversible changes that may cause problems for future generations, are an important influence on attitudes (e.g. DTI, 2003).

Knowledge and acceptability

Evidence is mixed about the effects of existing and new knowledge on attitudes to GM. The Eurobarometer (2006) found no difference in levels of support between those claiming to be familiar with GM and those who were unfamiliar, although those with better understanding were slightly more likely to judge GM to be morally acceptable (Gaskell et al, 2006). Similarly, Traill et al (2004) find that perceived knowledge is consistently insignificant as a driver of attitudes.

Other studies found that increased knowledge is associated with more positive views (for example, Grunert et al, 2004), and Costa-Font et al (2008) pointed out that the association between higher levels of knowledge and more positive attitudes is illustrated by the more positive attitudes of scientists and experts compared to the negative attitudes of the public.

One consequence of low knowledge and high uncertainty is that the attitudes and behaviours of those around us become an important consideration. The evidence indicates that social norms are a key factor in shaping attitudes to GM: for example, Saba and Vassalla (2002) found a stronger relationship between others' attitudes and participants' intention to eat GM food, than between participants' own attitudes and their intention to eat GM.

Top down attitude formation

Many studies find that general attitudes, rather than knowledge of GM, are the basis of attitudes towards this technology (e.g. Costa-Font et al, 2008; Rimal et al, 2005; Hossain et al, 2002[34]; Gaskell et al, 2006). This is summarised by Grunert et al (2004) as the difference between 'top down' and bottom up' processes of attitude formation. Top down processes involve the formation of an attitude in line with existing, higher level socio-political views, whereas 'bottom up' attitudes form on the basis of specific knowledge about that product or topic. Especially in complex, largely unknown subject matter, attitudes are more influenced by 'top down' processes than 'bottom up' processes (Grunert et al, 2004).

In line with this, evidence suggests that, in the case of risk, evaluations are based on perceived risks, rather than information from experts (Costa-Font et al, 2008; DTI, 2003), which indicates that perceived risks are formulated in line with top down attitudes, rather than knowledge of the topic. This in turn suggests that further information about the processes and products that fits with general attitudes is more likely to be 'heard', whereas information that conflicts with these general attitudes may have little effect.

Emotional/affective response

A perceived lack of knowledge about the subject matter causes the majority of people (in a survey situation) to give an emotional or affective response to the idea of GM, rather than a reasoned, thought through position (Gaskell, 2006; FSA, 2003). In general, people's associations are negative (FSA, 2003; Gaskell et al, 2006): for example, 25-35% of Europeans agreed with 'menacing image propositions' suggested to them [Note 4], demonstrating an inclination to assent to associations with adulteration, infection and monstrosities (Gaskell et al, 2006). However, as the authors note, this "does not mean that respondents held these views before being asked the questions in interview; it is likely that a combination of uncertainty about GM in general, unease about technology and anxiety about food causes people to assume the worst."

[33] Review of several large scale quantitative studies
[34] n = 989, telephone survey

Trust and information sources

In most locations, the media, government and industry emerge as the least trusted sources of information (Costa-Font et al, 2008; Cormick, 2007; DTI, 2003; Rigby et al, 2004; Hossain et al, 2002), and any information that comes from biotechnology companies is highly mistrusted (IGD, 2008; DTI, 2003). In the UK, consumers are sometimes suspicious that the government has already made a decision about GM and the public debate will be ignored (DTI, 2003). Some are also sceptical that the government has sufficient knowledge and expertise to ensure safety, and that official interests may be in line with industry rather than with consumers (ibid) [Note 5].

Greater trust in authorities is associated with more positive attitudes towards GM (Chen and Li, 2007; Costa-Font, 2008, Traill et al, 2004), and it is interesting to note that some research suggests a significant "trust divide" between Europeans and North Americans, with the latter trusting their regulatory authority more (Costa-Font et al, 2008). Similarly, Traill et al (2004) found that those who trust government and the food industry tend to think GM technology is less risky, whereas those who trust 'activists' (such as consumer and environmental groups) believe the opposite. Their research suggests that Americans are more trusting of the former, Europeans of the latter (Traill et al, 2004).

In both the EU and the USA, there is generalised support for tighter regulation (DTI, 2003; Mellman Group, 2006), but survey respondents are often unsure of how existing regulation works (Mellman Group, 2006; FSA, 2003) and exactly how GM should be regulated (FSA, 2003). Labelling emerges as one important tool for building trust by increasing feelings of control and choice (Costa-Font, 2008; Saba and Vassalla, 2002), and most studies find generalised support for clear labelling systems (e.g. FSA, 2003; DTI, 2003; Cormick, 2007; Rigby et al, 2004[35]).

In general, consumers appear to be unsure of whom to trust. One study that asked people which information sources they trusted found that the only answer mentioned by more than 10% of people was universities/educational establishments (Rigby et al, 2004). Other research indicates that consumers do not rely exclusively on official sources of information, but are more likely to use sources that mean something in their personal lives, such as their friends and family (DTI, 2003; Mellman Group, 2006).

Do different types of people hold different views?

Studies in different locations using different questions consistently find women to be less positive, more concerned, perceive fewer benefits and state they are less likely to eat GM food than men (FSA, 2003; Mellman Group, 2006; DTI, 2003; Saba and Vassalla, 2002; Gaskell et al, 2006). This finding is likely to have a complex and multifaceted explanation, but it may be partially explained by the fact that women are more likely to be responsible for food at the household level and, as we saw above, health risks to family are an important driver of negative attitudes to GM foods.

Aside from the persistent gender gap, the evidence surrounding the effects of other socio-demographic characteristics is less firm, and findings (some of which are listed below), are mixed and sometimes contradictory:

- the ABC1 group is more likely to be concerned about GM food (FSA, 2003; DTI, 2003 – both UK);
- lower levels of education are correlated with more negative attitudes (Saba and Vassalla, 2002 - Italy; Traill et al, 2004 – UK, US and France);
- the middle aged group (ages 36 – 49) is the most concerned (FSA, 2003 - UK);
- the over 65s are the most concerned (Gaskell et al, 2006 - EU);
- women, the 36-49 and over 65 age groups, and socio-economic group DE were the main drivers of decreasing concern between 2000 and 2003 (FSA, 2003 - UK).

Furthermore, Costa-Font et al (2008) cite two studies that found no significant relationship between socio-demographic characteristics and attitudes to GM, and even the gender gap does not hold in some sections of society, for example, amongst those with high levels of environmental concern (Frewer et al, 1998, cited in Costa-Font et al, 2008). The complexity of

[35] n = 608, random sample

this evidence reflects the fact that, as Cormick (2007) points out, there is not a single 'public,' and individuals are not simply defined by socio-economic group or gender, but are better thought of as 'bundles of attributes' (Verbeke, 2005). It also again suggests that it is difficult to compare results based on different survey questions carried out at different times.

How do views affect food behaviour and choices?

The consensus from the large body of evidence on this topic is that stated preference methodologies are not a reliable guide to how people behave and the choices they actually make (e.g. Costa-Font, 2008; Cormick, 2007; Gaskell et al, 2006), in part due to an idealised view about their own shopping habits in terms of buying 'healthy' and 'green' food and avoiding modern processing methods (Cormick, 2007). Moreover, in the hypothetical situations posed by survey questions, respondents may answer as citizens, in accordance with their 'top down' socio-political value framework, rather than consumers (Gaskell et al, 2006).

In terms of reported effects on behaviour, the FSA (2003) found that three out of four people claim that concern about GM food and ingredients affects their purchasing behaviour, and according to the IGD (2008), one person in five checks food labels for GM ingredients. However, in experimental settings, the majority of people are willing to taste GM food, which indicates that concerns are not as strong as many surveys suggest (Townsend and Campbell, 2004[36]; Cormick, 2007). In qualitative research conducted on behalf of the FSA (2003), various participants commented that they had noticed the introduction of a range of GM-free food at the supermarket Iceland, which, they felt, implied that the other food contained GM ingredients; however, they did not report that this had had any effects on their behaviour.

In recognition of the limitations of reported behaviour methodologies, several researchers have tried to recreate 'real life' shopping situations to monitor how consumers behave, with mixed results. For example, Rigby et al (2004) found that consumers are willing to pay a premium to avoid bread containing GM ingredients [note 6]. However, in another study of purchasing behaviour at roadside fruit stalls (Knight et al, cited in Cormick, 2007), 2,700 participants in six countries were asked to choose between organic fruit, fruit produced with chemical sprays and spray-free GM fruit. In three of the countries, the GM food was the preferred choice [note 7]. The authors note that this may be partly because of the higher price of the organic fruit; however, this result indicates that, for a majority of participants in those countries, price considerations are more important in a real purchasing situation than concerns about GM.

The relationship between concerns about GM food and the purchase of organic food is a recurring theme (Rimal et al, 2005; Cormick, 2007; Mellman Group, 2006; FSA, 2003). Rimal et al found that concern about GM is an explanatory variable in an individual's likelihood to buy organic food, and other studies find that attitudes to food in general (for example, how healthy it is, whether it is organic, whether it is 'environmentally friendly') are important predictors of attitudes to GM food.

Attitudes, whether positive or negative, are driven by a complex range of variables. However, it is interesting to note that, in general, attitudes to GM tend to be more positive where GM food is widely available, and less positive where there is ongoing debate about their acceptability. For example, in Taiwan, GM food is widely available, clearly labelled and is generally cheaper than other food, and attitudes in that country are positive overall (Chen and Li, 2007). Similarly in the USA, research has shown that becoming aware that GM food is widely available significantly increases positive attitudes (Mellman Group, 2006) [note 8].

Overall, it is difficult to know how stated intentions translate into actual purchasing behaviour. There is strong evidence that the relationship between the two is minimal. Sosin and Richards (2003) cite the case of rbST, a genetically engineered bovine growth hormone that increases milk production in cows that has been used since 1994 in the USA. Numerous polls reported widespread concern and experts predicted a 4 to 20 percent drop in milk consumption if rbST was introduced. As the authors say, "Predictions…proved to be wildly inaccurate, and milk consumption does not seem to have been affected."

[36] 'Topic blind' recruitment of 100 participants; questionnaires and taste tests

How have views changed over time?

Unsurprisingly, awareness of GM tends to track media attention, including attention on related issues (and not just about food); for example, survey data show that awareness of GM food peaked in the USA soon after the news of Dolly the sheep (Hoban, 2004). However, the non-comparability of different surveys - and even the same surveys over time - makes it difficult to draw firm conclusions about overall trends.

In the USA, the Mellman Group (2006) concluded from its review of regular polls conducted by the Pew Initiative on Food and Biotechnology that the public is forming firmer opinions: the proportion of people who supported or did not support GM steadily increased between 2001 and 2006, and the number of people who did not have an opinion declined. However, in the UK, a recent survey and review by the IGD (2008) found that views have remained stable over the last five years.

The Eurobarometer (2006) shows that European views are highly volatile: after a decrease in support between 1996 and 1999, there was an increase between 1999 and 2002 and then a steep decline to 2005, with the overall trend being a decrease in support. As in the USA, the number of people in Europe with no opinion decreased. However, in the EU, people have become less willing over time to discount the perceived risks of GM: the downward trend in support was due to a larger proportion of people moving out of the risk tolerant category into the outright rejecter category, offsetting the slight increase in outright support (Gaskell et al, 2006).

In sum, it is difficult from the available data to conclude any firm overall trends in attitudes to GM over time; however, it is fair to say that there have been no significant movements in either direction, and views (at least in the EU) seem to oscillate around a mid point of ambivalence.

Summary

Overall, the public seems to be at best uncertain and at worst negative about GM food. It is obvious that GM is not a clear cut issue that consumers simply support or do not support - most people sit on the fence. It is also clear that wider social, ethical and political concerns are at least as important as the products themselves in the formation of attitudes to GM [note 9].

It is interesting to note the higher levels of acceptability in locations where GM is widely available, which seems to suggest that familiarity leads to acceptability. However, the relationship between positive public attitudes and availability is likely to be a two way street, and more research would be required to investigate how this relationship works.

3.2 Cloning

Chapter 3.2 summary | **Cloning**

- **General awareness of cloning is high, although understanding of the science is limited**
- **Public attitudes are unsupportive of animal cloning for food production**
- **Safety concerns are often linked to past food crises such as BSE – consumers are sceptical of government's ability to ensure safety**
- **The majority of the UK public, however, remain uncertain and undecided**
- **There is widespread suspicion that big business will be the main beneficiaries of this technology**

There is a much smaller amount of evidence available about public attitudes to animal cloning for food than there is about public attitudes to GM food, and most work on cloning is conducted in the context of biotechnology in general. The most comprehensive survey available that includes the UK is the Eurobarometer, and most reports on European and UK public opinion draw on this source.

The largest body of survey data comes from the USA and gives snapshots of samples of the population (generally about 1,000 people) at different times. These results are only comparable at the highest level, due to the different methodologies and questions.

There is very little qualitative research available, and, given the limitations of large scale quantitative surveys in openly exploring perceptions, and the emotional/affective nature of public attitudes towards animal cloning, this is perhaps a gap to be addressed.

What are the public's views?

High awareness, but only basic understanding

Awareness of animal cloning is high both in the UK and in the EU overall: when interviewed for the Eurobarometer survey (2008)[37] for example, 86% of UK respondents selected the correct explanation of cloning from a list of choices[38] (the figure stood at 80% in the EU as a whole). Just 9% (7% in the EU) claimed never to have heard of cloning. In contrast, however, when unprompted, UK consumers in a different study were much less confident in their own knowledge and rated themselves at an average of two or three out of ten for understanding (Creative Research, 2008)[39].

A similar picture emerges from US research: Storey (2006)[40] reported that 59% of American consumers claim to understand cloning, but that understanding was mixed: three out of four correctly answered that cloning produces animals that are identical to their parents, but despite this, 59% thought (incorrectly) that cloning involved genetic modification. In line with this finding, Hallman (2006)[41] argued that, although most of the American public had heard of animal cloning, they knew little of the science behind it [note 1].

Food applications of cloning are the least acceptable

According to the Eurobarometer study, animal cloning for food is the least acceptable application of the technology: 58% of EU citizens (45% in the UK) thought it could never be justified. EU citizens were more willing to accept cloning in other circumstances though, for example, for the preservation of endangered animals and to improve resilience of animals against disease (Gallup/Eurobarometer, 2008) [note 2]. Nonetheless, it has been argued that animal cloning, even when described in the context of potentially beneficial medical applications, is seen by many as risky, morally unacceptable and not to be encouraged (Gaskell, 2007)[42]. Echoing this, 63% of

[37] Representative sample of 25,000 (1000 respondents from 25 EU countries)
[38] 'Cloning is making an identical copy of an existing animal'
[39] 4 deliberative reconvened workshops with 16-18 participants in each. Participants attended two 3-hour workshops in between
[40] Telephone survey of 1,040 adult Americans (523 men, 517 women; weighted total = 1,000) using a national probability sample of individuals 18 years of age and older, living in private households in the continental United States
[41] Media analysis and interviews with 10 opinion leaders
[42] Evidence review

respondents in an Ipsos MORI study stated that the risks of cloning in general outweighed the benefits (Ipsos MORI, 2005)[43].

The public is not generally supportive

Attitudes to using cloned animals as a food source tend towards the negative both in Europe and in North America; for example, 84% of Europeans said that we do not know enough about the long term health and safety effects of using cloned animals for food, while three-quarters agreed that there could be ethical grounds for rejecting animal cloning (Gallup/Eurobarometer, 2008). Similarly, just 25% of Canadians (Einseidel, 2005)[44] and 15% of US consumers (Gaskell, 2000)[45] support the use of cloned animals for food, and around two thirds of Americans are uncomfortable with animal cloning in general (Mellman Group, 2006)[46].

The majority of people in both the EU and the USA think that animal cloning for food is unnecessary (80% and 60% in Gallup/Eurobarometer (2008) and Lassen (2005)[47] respectively) and 80% of Europeans disagree that animal cloning is needed to maintain competitiveness in the food industry (Gallup/Eurobarometer, 2008). Qualitative work commissioned by the FSA (COI/Creative Research, 2008) indicated that a large proportion of people in the UK have neutral or undecided views [note 3], but when their perceptions were explored, they were found to be more similar to those of the outright rejecters than the outright supporters.

'Soft' opinions

As with other biotechnology applications, it seems that a large proportion of the public does not have a firm view; Sosin and Richards (2003)[48] wrote that public opinion on animal cloning for food is 'soft' – that is, that views are still being formed.

Several studies find mixed views on the subject; for example, Gaskell (2007) finds an equal divide between those willing to accept meat from cell cultures and those who would not accept it. When presented with a list of potential benefits of animal cloning for food production and asked to choose the two most important, 22% of UK consumers answered that none of the benefits justified the technology, but 45% of people selected two benefits/justifications and 12% selected one (Gallup/Eurobarometer, 2008). Priest (2000)[49] and Einseidel (2000)[50] found that two thirds of Americans thought animal cloning in general to be "useful," 63% thought it to be "risky" and 54% considered it morally acceptable. However, views on animal cloning for food are likely to be more negative that this suggests since other studies have shown food to be less accepted than other applications.

The variability of results from different surveys highlights the effects of survey design and methodology on outcomes, and suggests that views on animal cloning are somewhat malleable. However, the body of evidence gives the overall impression that public attitudes to cloning for food tend to be cautious and unsupportive.

What shapes the public's views?

Risks and benefits

As we have seen in sections 3.1 (GM) key factors in shaping public attitudes to novel technologies generally are the perceived usefulness/need for the technology and the perceived risks/ethical concerns. Technologies that are low on the former and high on the latter are unlikely to attract public support (Gaskell, 2000). Unprompted, research participants often struggle to identify

[43] Representative sample of 1,831 UK adults, 2004
[44] Evidence review
[45] Discussion paper based on evidence review and findings of one day stakeholder workshop run by the European Food Safety Agency (EFSA)
[46] Review of polls conducted on behalf of the Pew Initiative on Food and Biotechnology between 2001 and 2006
[47] This report is one of the summaries from *Farm Animal Cloning and the Public: A project to facilitate a European public debate and to make recommendations on regulation and on guidelines for research and applications of farm animal cloning* - a project run by the Danish Centre for Bioethics and Risk Assessment under the Sixth Framework Programme of the European Commission. Findings are based on a series of engagement activities with stakeholder groups including the public, scientists, NGOs and the food industry
[48] Nationally representative survey of 1,005 adults (2005). Also includes findings of other research, including surveys by the International Food Information Council (IFIC) (nationally representative survey of 1,000 adults, 2005) and the Food Policy Institute at Rutgers University (nationally representative survey of 1,201 adults, 2003)
[49] Random digit dial phone survey of 1002 respondents
[50] Telephone survey of a random sample of 1000 adults

benefits of animal cloning for food (Creative Research, 2008; Hallman, 2006), but are keenly aware of the risks and ethical issues (see below) and this would suggest a lack of public support.

Additionally, attitudes towards cloning (and biotechnology in general) follow a "hierarchy of acceptability" (Gaskell, 2000; Einseidel, 2005; Lassen, 2005): applying technologies to micro-organisms causes little concern, but applications involving the 'higher' animals and humans are much less acceptable. The combination of these two axes of attitude formation – risk/benefit perceptions and the hierarchy of acceptability – combine to produce a public mood of unease and caution about animal cloning for food (Gaskell, 2000).

The real winners are the biotechnology and food industries

The benefits of animal cloning for food identified by research participants tend to link to economic rather than consumer benefits: as with other forms of agricultural biotechnology, consumers feel that the real winners from animal cloning will be the biotechnology and food industries (Gallup/Eurobarometer, 2008; Hallman, 2006; Creative Research, 2008). Benefits to industry are not perceived as consumer benefits, and so do not figure in consumers' cost-benefit evaluations (Gaskell, 2000).

Ethical concerns

As with GM food, it seems that animal cloning is not a topic at the forefront of people's minds, but that when people engage with the topic, they can form strong views (Creative Research, 2008; Gallup/Eurobarometer, 2008; Mellman Group, 2006). Around three quarters of people in the UK have ethical concerns about animal cloning for food (Gallup/Eurobarometer, 2008): many are concerned about "playing god" (Hallman, 2006) and a common worry is that animal cloning will inevitably lead to human cloning (Gallup/Eurobarometer, 2008; Hallman, 2006; Creative Research, 2008). A majority of people find the idea of cloning "unnatural" (Einseidel, 2000)[51], and a step too far in interfering with mother nature (Gaskell, 2000); even among supporters of animal cloning in the EU, 64% agree that "cloning threatens the natural order" (Lassen, 2005) [note 4]. People also incorporate their perception of the moral status of animals into their evaluations [note 5].

There is some evidence that UK consumers have fewer moral concerns than the rest of the EU: many UK consumers stop short of saying that animal cloning is morally wrong, whereas this view is more widespread elsewhere in the EU (Gallup/Eurobarometer, 2008) [note 6].

The importance of the moral debate in public opinion formation is highlighted by Lassen (2005), who cites several studies that show moral assessment to be the most important driver of acceptability. According to Lassen's summary, usefulness is a precondition for acceptability of novel technologies, and people are willing to accept some risk as long as this is balanced by usefulness and an absence of moral concerns. However, moral discomfort can act as a veto irrespective of a positive evaluation of other risks and benefits [note 7]

Other concerns

Safety concerns are often linked to past food controversies – BSE and GM food are often cited - and perceptions of these issues seem to contribute to people's suspicion of novel food technologies such as cloning. Suspicion is also driven by the common perception of a high incidence of miscarriage and deformed or short-lived offspring derived from cloning, which deepens the sense of unnaturalness (Creative Research, 2008). The word 'cloning' has also been found to cause discomfort and conjure "dystopian images" in the public imagination (Gaskell, 2000; Einseidel, 2005).

Other sources of caution and negativity include concerns for animal welfare (Creative Research, 2008) and the risk of treating animals as commodities rather than "creatures with feelings" (Gallup/Eurobarometer, 2008) [note 8]. People are worried about the safety of food from cloned animals and the introduction of new diseases (Creative Research, 2008). Consumers also express concern about the technology "falling into the wrong hands" (Hallman, 2006) [note 9]. Finally, many consumers are worried that the introduction of cloning may create a two-tier market where only the better off could either afford the better food (created from cloning) or avoid cloned food (if it was cheaper and seen as poorer quality). The other side of this coin is that perceived

[51] Telephone survey of a random sample of 1,000 adult Canadians, February 2000

benefits to society as a whole have a large, positive effect on acceptability rates (Sosin and Richards, 2005).

It is clear from the research that attitudes to food products derived from clones and their offspring are not informed simply by an evaluation of the products themselves, but are contextualised by a whole host of socio-political drivers, including concerns about social equity, animal welfare, and attitudes to science and nature. The importance of these wider factors in shaping public opinion is highlighted by the difference in levels of support for animal cloning in general between the public and scientists (25% and 60% respectively) (Einseidel, 2005).

Trust and sources of information

The majority of people feel uninformed about animal cloning and expect to rely on trusted sources such as the government and regulators to make decisions and ensure safety (Hallman, 2006; Gaskell, 2000). However, most research suggests that people do not feel they can trust these authorities and are suspicious of their motives (Hallman, 2006; Gaskell, 2000; Creative Research, 2008; Einseidel, 2005; Storey, 2006). For example, many people in the Creative Research (2008) deliberative workshops were sceptical of regulators' ability to ensure safety and cited the BSE crisis as an example (see also Hallman, 2006). Some participants even felt that food from clones was probably in the food supply already without us knowing, or that it would be whatever public opinion was.

The principal source of information about cloning is the mass media (Priest, 2000; Hallman, 2006; Einseidel, 2000), suggesting that media portrayals of cloning are a key factor in public perceptions.

Knowledge and the effects of information

Evidence regarding the effects of more information about animal cloning on people's attitudes is somewhat mixed. On one hand, Sosin and Richards (2003) found that further information about the process of animal cloning made people more comfortable [note 10]. However, the Creative Research (2008) study concluded that as participants found out more about animal cloning, their levels of concern increased [note 11].

As we have already seen, the evidence in general suggests that opinions on animal cloning are uncrystallised (Hallman, 2006) and particularly sensitive to information, especially information that resonates with the overall sentiment of unease. People's reactions in a research context tend to reflect an emotional or affective response to the idea of animal cloning, rather than expressing a thought out view based on knowledge of the process of cloning (Hallman, 2006; Einseidel, 2005). Einseidel (2000) finds that general attitudes are a strong predictor of attitudes to animal cloning for food, indicating that 'bottom up' information may not be sufficient to counteract the effects of people's 'top down', general attitudes, which are a more important driver of attitudes in most situations of limited knowledge and understanding (Grunert et al, 2004).

Do different types of people hold different views?

In the UK, Europe and the USA, women are significantly less positive than men about animal cloning for food production and state that they are less likely to buy food products from clones and their offspring (Creative Research, 2008; Gallup/Eurobarometer, 2008; Storey, 2006) [note 12]. The Eurobarometer (2008) also provides further evidence about the varying levels of knowledge and awareness of different segments of the EU population:

- men, younger respondents, the more highly-educated and city dwellers were more likely to identify the correct explanation of animal cloning from a list and more likely to reject the statement that cloning involved genetic modification;
- city dwellers are more accepting than rural inhabitants: 37% of city dwellers would buy meat or milk that came from cloned animals and their offspring compared to 30% of rural residents;
- the older age group is less positive: more than half of over 55s said it was not at all likely that they would consume meat or milk that came from cloned animals or their offspring, compared to fewer than three in ten 15-24 year-olds.

How do views affect food behaviour and choices?

In many surveys on animal cloning for food production, willingness to purchase questions are included with other questions about acceptability and perceived benefits and risks. Purchase intention tends to follow the same patterns as general attitudes – those with negative attitudes are less likely to buy or eat products from clones and their offspring (Gallup/Eurobarometer, 2008; Gaskell, 2007; Storey, 2006) [note 13].

Overall, the evidence suggests that people are generally unwilling to buy food products derived from clones and their offspring; however, it is clear that stated intentions in this area (as in other areas of biotechnology), are a poor guide to actual consumer behaviour (Sosin and Richards, 2005; see chapter on GM food for more details). Further field research would be required to test whether this sentiment would be borne out in purchasing behaviour, if such products were introduced to the market.

How have views changed over time?

Due to the malleability of views and, consequently, the strong impact of question wording on survey results, it is only possible to derive topline trends on how views are changing over time from the existing body of evidence. The non comparability of different studies is magnified by the sensitivity of public opinion to contextual factors such as media stories. However, there is some evidence that awareness of animal cloning (although not necessarily food applications of the technology) has risen over time; for example, when asked what the term 'biotechnology' brought to mind, in 1997 just 3% mentioned cloning, whereas in 2000, 11% mentioned cloning as a first answer and a further 11% mentioned it as a second answer (Einsiedel, 2000) [note 14]..

There is little evidence about views over time in the EU and the UK. The most important tracker survey is the Eurobarometer; however, recent reports do not include changes over time for animal cloning since the questions have changed.

Summary

Overall, the evidence suggests that public opinion about animal cloning for food ranges from uncertainty to scepticism. However, reactions tend to be emotional rather than reasoned, indicating that views are still being formed. Animal cloning is not a front of mind concern for the majority of consumers and responses in a survey or research situation are not indicative of how these semi-formed views would translate into purchasing behaviour.

It is crucial to acknowledge that views on animal cloning are formed in the context of much wider socio-political drivers, and attitudes towards science, technology, the environment and ethics play a large part in people's evaluations. This suggests that a public engagement strategy on animal cloning that omitted these wider factors would run the risk of embedding negative views and increasing mistrust in science and government.

3.3 Nanotechnologies

Chapter 3.3 summary | **Nanotechnologies**

- **Awareness of nanotechnologies is low, and although general attitudes towards them seem fairly positive, people seem less convinced about the potential benefits of food applications and are sceptical about why these are being developed**
- **In general, use of nanotechnologies in packaging may be seen more positively than their use in food *per se***
- **Women seem to perceive fewer potential benefits from food applications than men and seem less likely to want to buy food that has been treated using nanotechnologies. Meanwhile, older people may be more likely than others to see usefulness of packaging applications**
- **Concerns towards nanotechnologies in general include their effectiveness, long-term side-effects and the ability of regulators and others to ensure safety and to ensure that developments benefit the general public**
- **Other factors affecting peoples' attitudes towards nanotechnologies include their scientific knowledge, their general outlook/ worldview and where they have received information from**

A great deal of information was uncovered on public attitudes towards nanotechnologies, however most of the reports reviewed focussed on nanotechnologies *in general*. The studies ranged from nationally representative quantitative samples, to exploratory qualitative research, along with documentation and evaluation of public engagement attempts. Much of this material was from the US and Canada, although five studies were from the UK (only one of which involved quantitative research with the general public). The four studies reviewed that specifically focussed on *food* tended to test participant reactions to information presented rather than prior awareness or knowledge of nanotechnologies (e.g. Siegrist et al., 2008; 2007; Cook and Fairweather, 2007).

It is interesting to note that there seems to be an emerging consensus that public attitudes to nanotechnologies are in the process of being formed. As Lee et al. (2005) wrote, "public opinion on nanotechnology is in the early stages of the issue cycle and -as a result- still very much in flux".[52]

What are the public's views?

Awareness

Various studies have shown that there is still a very low level of awareness of nanotechnologies in general, both in the UK and abroad. A nationally representative survey conducted in the UK in 2004[53] for example, found that just 29% said they had heard of the term and, when asked to describe what nanotechnologies were, only 19% were able to offer any form of definition (the Royal Society & the Royal Academy of Engineering, 2004). More recently, results from a survey conducted in the US in 2007[54] showed that 92% had heard either 'little' or 'nothing' about nanotechnologies (Kahan et al, 2008).

Attitudes towards nanotechnologies in general

While awareness appears to be low, many studies show that attitudes towards nanotechnologies in general are fairly positive. The results of the Royal Society and the Royal Academy of Engineering (2004) survey (mentioned above) showed that in the UK, of those who understood what nanotechnologies were, 68% thought they would make life better in the future, while only 4% said they would make things worse. Other studies have supported these findings - both in the UK and in the US (e.g. Lee et all[55], 2005 [note 1]; Macoubrie, 2005[56] [note 2]). Nevertheless,

[52] This view was repeated during the expert interviews
[53] n=1005, nationally representative sample of people aged 15 or over in Great Britain
[54] n= 1600, drawn from a nationally representative online survey panel
[55] n=706, nationally representative telephone survey
[56] 12 groups, with a total of 177 participants in 3 locations: Spokane, Washington; Dallas, Texas; and Cleveland, Ohio.

support has been qualified: a UK citizens' jury on nanotechnologies for example raised a number of concerns about how nanotechnologies would be developed (Nanojury UK[57], 2005) [note 3].

Attitudes towards nanotechnologies in food

As already highlighted, many of the studies we uncovered which focussed on the use of nanotechnologies *in food* investigated perceptions of risks and benefits and what shapes people's views rather than looking at attitudes overall. The information presented to respondents plays a particularly important role in this context and in some cases we have had reservations about how this was done. One New Zealand study[58] (Cook and Fairweather, 2007) recorded very positive results towards buying lamb or beef that had been altered using nanoparticles for instance (80.4% agreed with the statement "it would be wise for me to buy this product"); however, this seems at odds with much of the other research undertaken, and it is likely that the positive outcome was due to the positive nature of the information given to participants [note 4].

Other studies have found more negative attitudes towards the use of nanotechnologies in food, and there appears to be much less enthusiasm towards their use *in food* than in other applications. During the *Nanodialogues* experiment[59] for example, participants questioned whether there was any need for them [note 5]. Another UK study[60] also found a lack of support for nanotechnologies in food. During interviews with representatives from civil society, the majority seemed convinced that there would be "a public backlash against the use of nanomaterials in areas such as food and medicine" (Nanologue, 2006).

This lack of enthusiasm for using nanotechnologies in food also seems present in the US. During focus groups[61] in which participants read information about emerging applications for nanotechnologies and were asked to identify areas of particular interest, food and nutrition benefits were mentioned just 21 times out of 349 (Macoubrie, 2005) [note 6].

There is some evidence that applications for nanotechnologies in food packaging are seen in a more favourable light than food applications: a Swiss study[62] of the perceived risks and benefits of different applications in food and food packaging (Siegrist et al, 2008) showed that applications that were ingested (e.g. modified foods, nutritional capsules) were generally seen as higher risk, and of lower benefit than those applications related to food packaging (e.g. UV protection packaging, salmonella detectors) [note 7].

What shapes the public's views?

Most of the work uncovered on this topic focussed on nanotechnologies in general, rather than specific applications. It is relevant to our study though as it may provide insight into how public opinion on its use in food might develop.

Knowledge

Some studies suggest that participants' levels of knowledge are important in determining their viewpoints on nanotechnologies. A US study by Kahan et al. (2007[63]) for example, found that participants with low professed levels of knowledge about nanotechnologies were more likely to think that risks outweighed benefits, whereas the opposite was true for those with higher professed levels of knowledge [note 8].

Another US study (Lee et al, 2005[64]) showed that higher levels of scientific knowledge were correlated to stronger perceptions of benefits outweighing risks as well as more general support

[57] Citizens' jury involving 15 people from West Yorkshire, with ten sessions over five weeks
[58] n=565, non-representative postal survey
[59] which convened a small group of members of the public, in a similar vein to citizens' juries, to conduct a "People's Inquiry" into nanotechnology.
[60] based on a consultation with representatives from research, business and civil society
[61] 12 groups, with a total of 177 participants in 3 locations: Spokane, Washington; Dallas, Texas; and Cleveland, Ohio.
[62] n=337, non-representative postal survey of the German-speaking part of Switzerland
[63] n=1,850, drawn from an on-line survey panel and weighted to reflect the national profile
[64] n=706, nationally representative telephone survey

for nanotechnologies. Knowledge about nanotechnologies specifically did not seem to have a major effect though. Lee at al. concluded that since "*nanotechnology knowledge levels among the general public are still reasonably low and mass media discuss the issue mostly in terms of economic benefits and scientific merits … audiences rely on heuristics provided by mass media rather than on nanotechnology knowledge that they simply do not have at this point*." This does not suggest, however, that knowledge will not play a role in shaping public views as more information becomes available and as knowledge about nanotechnologies increases.

Risk-benefit perceptions

In the UK *Nanologue* study (2006)[65] participants were asked unprompted about which ethical, legal and social risks and benefits were relevant to the nanotechnologies debate. *C*ivil society[66] participants listed three times more risks than benefits. The *Nanodialogues* study[67] also revealed serious concerns amongst participants, with *uncertainty* being a particular worry [note 9]. Concerns expressed in other studies included whether nanotechnologies would work (particularly for applications in the human body) and their long-term side effects (Royal Society and Royal Academy of Engineering, 2004[68]), 'messing with nature' and 'playing god' (Macoubrie, 2005[69]). Despite these, participants were often positive about the potential benefits they could bring. The positive but cautious nature of overall attitudes (both in Europe and the US) is supported by many studies e.g. Kahan et al. (2007) [note 10], Lee et al. (2005) [note 11], Macoubrie (2005) [note 12] and The Royal Society and The Royal Academy of Engineering (2004) [note 13].

There are similar concerns about applications for nanotechnologies *in food* but people seem less convinced about the potential benefits that food applications might bring. This may go some way to explaining lower levels of enthusiasm.

In the UK, the 2006 *Nanologue* study highlighted areas of perceived risks in relation to food. A third of all civil society interviewees displayed concern about food becoming toxic and causing damage to human health for example (although there was also recognition of the potential benefits; e.g. 'smart foods' to deliver drugs and nutrients, and potentially cheaper and safer food).

Even the Cook and Fairweather (2007) study[70], which claimed strong levels of support for food applications in New Zealand, found that greater proportions of respondents agreed with statements illustrating potential risks than with those outlining potential benefits [note 14].

Siegrest et al. (2008)[71] argued that risks and benefits are negatively correlated, in that those who perceive a greater number of risks associated with nanotechnologies' uses in food are also more likely to perceive a lower number of benefits. This seems in line with earlier work, although Lee et al. (2005)'s research[72] contradicts this [note 15].

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[65] which was based on a consultation with representatives from research, business and civil society

[66] The authors of the report defined civil society as the totality of voluntary civic and social organisations/ institutions which form the basis of a functioning society. However, for the purposes of the project they widened the group to include those involved or interested in understanding, marketing, regulating, monitoring or writing about nanotechnologies or helping to develop market-relevant products using nanotechnology applications.

[67] which convened a small group of members of the public, in a similar vein to citizens' juries, to conduct a "People's Inquiry" into nanotechnology.

[68] Two in-depth qualitative workshops (following the initial survey) in London (23 participants) and Birmingham (27 participants)

[69] 12 focus groups, with a total of 177 participants in 3 locations: Spokane, Washington; Dallas, Texas; and Cleveland, Ohio.

[70] n=565, non-representative postal survey

[71] n=337, non-representative postal survey of the German-speaking part of Switzerland

[72] n=706, nationally representative telephone survey

Trust in the grounds for development of new technologies and in regulation

In general, trust in scientists, government and companies is correlated with attitudes to nanotechnologies (e.g. Lee et al., 2005; Siegrist et al., 2007[73]) [note 16].

During consultations on nanotechnologies in the UK, the public questioned the trustworthiness of the authorities, scientists and private companies. Participants in the qualitative element of the Royal Society and Royal Academy of Engineering's research (2004) for example were somewhat unconvinced of the ability of these actors both to ensure safety, nationally and internationally, and to ensure that any developments of nanotechnologies would actually benefit the general public, and not simply increase the power and wealth of large corporations. Similarly, civil society representatives in the *Nanologue* (2006) study[74] were worried that the use of patents would further increase corporate power and create a "nano-divide" with only the wealthy really gaining. Meanwhile, participants in the *Nanojury UK* (2005)[75] recommended that any public money being spent should go towards solving health and environmental problems and should come with strings attached for the private sector.

UK concern about the regulatory framework within which nanotechnologies in general are being developed was stressed by Gavelin et al. (2007)'s research[76], who stated that "*participants were concerned with both uncertainty about the impacts of nanotechnologies … and about how those impacts are to be handled, and by whom*". Authors reporting on the Small Talk project[77] went further, suggesting that *"people are not concerned about specific risks arising from the technologies themselves but, rather, about the structure of regulation that they will have to rely on to deal with any risks"* (Smallman and Nieman, 2006[78]).

It is clear that previous experience contributes to a lack of trust – both in the US and in the UK. Macoubrie (2005)[79] for example, found that participants in US discussion groups would draw analogies with asbestos, dioxin, Agent Orange and nuclear power when discussing the risks of nanotechnologies and Stilgoe (2007)[80] revealed similar findings in the UK context [note 17].

Trust concerns amongst the public in relation *to food* echo those expressed in relation to general applications. The UK *Nanodialogues* project for example, found that there was real scepticism about the motives of private companies, and a sense that development of applications for nanotechnologies in food was more to do with making a profit than responding to a public need (Stilgoe, 2007) [note 18].

Cultural outlook and worldview

Although not specifically related back to food, a key driver of public opinion towards nanotechnologies in general appears to be people's pre-existing cultural outlook and worldview. This is linked not only to the fact that nanotechnologies are new and that people therefore have to rely on their existing knowledge to form their opinions, but also, that people make decisions by "*paying selective attention to [nanotechnology's] positive or negative aspects, perhaps in part because of pre-existing political predispositions or other social factors*" (Lee et al., 2005).

Priest (2006)[81] found that those who had more positive views of emerging science and technology generally, were significantly more likely to support the development of nanotechnologies [note 19].

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[73] n=153, non-representative survey of the German-speaking part of Switzerland, where only those responsible for grocery shopping qualified
[74] which was based on a consultation with representatives from research, business and civil society
[75] A citizens' jury involving 15 people from West Yorkshire, with ten sessions over five weeks
[76] A review of six experiments in engaging the public on nanotechnology (3 of which are covered in this study – Nanojury UK, Small Talk and Nanodialogues)
[77] The Small Talk project involved a series of 20 events to engage a range of different audiences on nanotechnology. A total of over 1200 participants attended events arranged by a variety of different organisers that all received support and guidance from the project.
[78] Report based on evaluations of each of the 20 events
[79] 12 focus groups, with a total of 177 participants in 3 locations: Spokane, Washington; Dallas, Texas; and Cleveland, Ohio.
[80] In a project which convened a small group of members of the public, in a similar vein to citizens' juries, to conduct a "People's Inquiry" into nanotechnology.
[81] Survey of 2000 Canadians and 1200 people in the US

Meanwhile, Kahan et al. (2007)[82] (who analysed public views according to two axes: "hierarchy-egalitarianism" and "individualism-communitarianism" [note 20]) found that where participants received substantial information about nanotechnologies[83], cultural outlooks strongly influenced views. Provision of information generated a "biased assimilation and polarization effect": individuals assimilated balanced information in a way 'biased by their cultural predispositions toward environmental risks generally' so that those with a hierarchical and/or individualistic viewpoint were more likely to see benefits outweighing risks whereas egalitarians and communitarians were more fearful and less convinced by the benefits [note 21] (Kahan et al., 2007).

Although based on the work of only one research team, there is evidence to suggest that the source of any information that people receive about nanotechnologies has a substantial impact on the effect that the information has. In their US survey [84] Kahan et al. (2008) found that the source of information was more important than an individual's own cultural outlook or worldview in determining how they would respond to the information provided. In circumstances where the advocate of an argument was seen to follow the expected viewpoint of his/her supposed cultural outlook[85] the polarization in views between participants sharing and those disagreeing with the views expressed (and between participants of differing cultural outlooks) became even greater [note 22]. Where advocates adopted viewpoints that were counter to their supposed outlook, participants tended to follow the viewpoint of those experts whose cultural outlook was similar to their own, rather than the viewpoint that would be suggested by their own worldview. Kahan et al. also found that where participants were equally likely to hear from people who did and did not share their world view on both sides of an issue, the polarisation described above was effectively eliminated.

Affect

Cultural views and world outlook along with other factors that shape people's views (e.g. trust and previous experience) are seen to determine people's affective or emotional responses to nanotechnologies.

Siegrist et al. (2008)[86] found that affect had a strong influence on the perception of risks and benefits of nanotechnologies in food applications. They reported that the more that negative affect was associated with a particular food or food packaging application, the higher the perceived risk, and the lower the perceived benefit [note 23] which echoed an earlier US study (Lee et al, 2005[87]) [note 24]. The US study also suggested that affect interacts with other factors in determining views on nanotechnologies – and notably, that knowledge about nanotechnologies had a much stronger influence on general support for nanotechnologies and on assessments of risks-versus-benefits where respondents also had low levels of negative emotion toward them. This led the authors to conclude that the key assumption made by the science literacy model (i.e. that knowing more about new technologies would make people more open towards them) only held if emotional responses did not 'override' cognitive considerations.

Do different types of people hold different views?

Many of the studies reviewed did not consider the influence of socio-demographic factors on perceptions of nanotechnologies. Nevertheless, the two studies which looked specifically at food found differing views between men and women and one of the two studies also found differences according to age in how useful the technologies presented were thought to be.

Gender

Overall, women seem less likely to think that the benefits of nanotechnologies outweigh its risks.

[82] n=1,850, drawn from an on-line survey panel and weighted to reflect the national profile
[83] as opposed to where they received minimal information (in which case cultural outlook had no effect)
[84] n= 1600, drawn from a nationally representative online survey panel
[85] e.g. speaking for or against the use of nanotechnology
[86] n=337, non-representative postal survey of the German-speaking part of Switzerland
[87] n=706, nationally representative telephone survey

- In their Swiss sample, Siegrist et al. (2008) [88] found that while gender did not seem to influence perception of risk for food or packaging, women perceived significantly fewer benefits for both applications.
- This was supported by results from New Zealand where men were found to be much more likely to buy lamb or beef that had been modified using nanotechnologies[89] (Cook and Fairweather, 2007).
- In the US, Kahan et al. (2007)[90] and Lee et al. (2005)[91] both found that gender played a role in risk-benefit perceptions of nanotechnologies *generally*, with men significantly more likely to think that benefits outweighed risks (or less likely to have negative emotions towards nanotechnologies – Lee et al.).
- In the UK context, the Royal Society and the Royal Academy of Engineering's study[92] found that awareness of nanotechnologies *in general* was higher amongst men but did not consider any attitudinal differences [note 25].

Age

There is a mixed picture in relation to age.

- In general, awareness of nanotechnologies seems slightly lower among older people (Royal Society and the Royal Academy of Engineering, 2004) – at least in the UK.
- Older people are also more likely to have negative affect towards them (Lee et al., 2005, using a US sample).
- However, there is some evidence, albeit from a relatively limited Swiss sample, that they may also be more convinced of the usefulness of the new technologies, particularly in relation to packaging (Siegrist et al. 2008) [note 26].

Other demographic factors

In the US Kahan et al. (2007) and Lee et al. (2005) both found higher levels of support for nanotechnologies amongst those educated to a higher degree and both also found African-Americans to be more likely to think risks outweighed benefits than whites (or that they were more likely to have negative emotions towards nanotechnologies – Lee et al)[93]. In addition, Lee et al. (2005) found that religious people were less likely to be supportive of nanotechnologies (and less likely to think that benefits outweighed risks) [note 27] [note 28].

In the UK, the Royal Society and the Royal Academy of Engineering's study found that awareness of nanotechnologies *in general* was higher amongst those in higher socio-economic grades.

How do views affect food behaviour/choices?

Our search uncovered no evidence of how people's views on nanotechnologies affect their food behaviour/choices, mainly due to the lack of nano-engineered food products on the market. Two studies did, however, provide some insight into how behaviour might be affected by measuring intention or willingness to buy. Cook and Fairweather (2007)[94] found that despite the numerous concerns mentioned, 76.6% of respondents agreed that if available they would definitely buy lamb or beef that had been altered using nano-particles. As highlighted earlier though, this result may have been affected by the study's framing of information on the benefits of nanotechnologies.

Meanwhile, Siegrist et al. (2007)[95] found that respondents were much less likely to buy food products that had been altered using nanotechnologies, though they were somewhat more positive about products with nanotechnology-enhanced packaging [note 29].

[88] n=337, non-representative postal survey of the German-speaking part of Switzerland
[89] n=565, non-representative postal survey
[90] n=1,850, drawn from an on-line survey panel and weighted to reflect the national profile
[91] n=706, nationally representative telephone survey
[92] =1005, nationally representative sample of people aged 15 or over in Great Britain
[93] n.b. in Kahan at al.'s study, the views of African-Americans and Whites became more polarised with the provision of detailed information
[94] n=565, non-representative postal survey
[95] n=153, non-representative survey of the German-speaking part of Switzerland, where only those responsible for grocery shopping qualified

How have views changed over time?

None of the studies reviewed made any attempt to assess how views had changed over time – either in relation to nanotechnologies in general or in relation to food.

Summary

There is very low awareness of nanotechnologies, particularly in relation to food. Despite this, various surveys on public attitudes have shown that views in general are fairly positive, if a little uncertain. There is less enthusiasm for food applications than other areas in which nanotechnologies might be used however, and attitudes towards food are slightly more negative. This is in part explained by the fact that, although concerned about the risks of nanotechnologies in all their forms, the public sees fewer potential benefits for food applications.

The studies reviewed highlight a range of factors that shape public opinion on nanotechnologies, including trust, experience of previous technological innovations, a sense of control, cultural outlook/worldview and the source from which they receive information about the technology – all of which impact on people's affective responses.

There are a number of socio-demographic differences in public views of nanotechnologies, the most significant of which appear to be gender and ethnicity (with men generally more positive than women) but very little is known about how these viewpoints might affect people's food choices/behaviours.

3.4 Irradiation

Chapter 3.4 summary | **Irradiation**

- **Public attitudes towards food irradiation are fairly negative, although they may vary depending on the type of food in question**
- **Attitudes are influenced by risk and benefit perceptions, and affected by information provision – negative information appears to have a much stronger impact than positive information**
- **The available evidence on how attitudes vary between demographic groups is inconclusive**
- **People with more positive views towards irradiation appear to be more willing to eat irradiated foods**
- **There is a lack of clear evidence on how views have changed over time**

The majority of the work on public attitudes to food irradiation has been carried out in the US, where irradiated foods are more widely available and where public awareness of food irradiation is higher than in many other parts of the world.

Research on public attitudes to food irradiation has mostly been carried out by academics, with a focus on questions such as acceptance of and willingness to consume irradiated foods, and the impact of information provision on those decisions. Where we have had to rely on less than robust data to help answer the research questions, the limitations of the data have been noted in the text.

What are the public's views on irradiation?

Much of the literature suggests that public attitudes towards food irradiation are, on the whole, negative (e.g. Gunes & Tekin, 2006, He et al., 2005a; Ronteltap et al., 2007). As touched on above, most of the work has focused on determining what proportion of the public is prepared to buy and/or consume irradiated food. Frenzen et al. (2000) noted that the answer is generally around 50% in the US, although they also pointed out that this number tends to be higher in those cases where respondents are first given an explanation of what food irradiation does – i.e. that it kills harmful bacteria in the food [note 1].

The views of the public on food irradiation also appear to vary depending on the type of food, with irradiation being perceived as more appropriate for particular foods, and unnecessary for others. For example, research by Johnson et al. (2004), again in the US[96], suggested that irradiation of fruit and vegetables may be perceived as more acceptable than irradiation of meat [note 2].

The main reasons given for opposition to food irradiation seem to be concerns over the safety of irradiated foods and uncertainty over the risks and benefits of the technology. For example, Frenzen et al. (2000) found that the most frequently cited reason why their respondents[97] would not buy irradiated meat or poultry was that they felt they had insufficient information about the risks and benefits of irradiation (35.0%), followed by concern about the safety of eating treated food (22.7%) [note 3]. Similarly, He et al. (2005a) found that safety concerns were the most common justification given by those who refused to buy irradiated beef [note 4].

Concerns over the safety of irradiated food, as well as a possible lack of knowledge about irradiation, are reflected in the findings of He et al. (2005b). When asked how they would react to a beef product labelled as irradiated, more than 30% of their respondents said they would consider it to be a warning, and would try to avoid the product. Just under 21% would see it as quality and safety assurance – which it is in fact meant to be. The remainder were either unsure or claimed to feel indifferent.

[96] n= 50, non-representative sample of consumers in Atlanta, Georgia
[97] n= 10,780, not strictly a representative sample of the US population

The literature highlights some of the negative connotations that the term 'irradiation' elicits in people's minds, which may help explain their negative attitudes. These include fear of the unfamiliar or fear that irradiation could make foods radioactive or form harmful compounds (e.g. Frenzen et al., 2001; Gunes & Tekin, 2006). Cardello et al. (2007) suggest that using different terminology could influence people's attitudes: their research[98], again in the US, found that people were less concerned about 'ionizing energy' than about 'irradiation' (bearing in mind they may not have known that the two terms have the same meaning in practice).

Public views on food irradiation in the UK

There is currently little available evidence about public attitudes towards food irradiation in the UK. The reviewed literature includes some, now rather out-of-date, secondary data: Yeung and Morris (2001) mention a survey carried out by the UK Consumers Association in 1990, which found that "over one-third of consumers did not favour the irradiation of food", and Wilcock et al. (2004) note that food irradiation is less accepted in the UK than it is in the US, but again their evidence for this statement comes from research carried out in the 1990s.

The only source identified during our literature search which presents primary research on attitudes to irradiation in the UK context is a survey[99] carried out in Scotland in 1998 by Grande et al. (1999). The results suggest that there is some concern among the Scottish population over the potential health implications of eating irradiated foods, to the extent that nearly 20% of the sample felt it was likely that they could suffer ill health as a result of consuming them (although more than half of the sample felt this was unlikely) [note 5].

Food irradiation in context

There is some suggestion that the public may not be as concerned about food irradiation as implied by surveys which directly ask what people think about this specific processing method. Fox et al. (2001) refer to a study carried out in the US in which people were asked to name food-related safety concerns. Less than 1% mentioned irradiation unprompted but when the same group was asked to select from a list which food safety issues they felt concerned about, the proportion mentioning irradiation rose to 33% [note 6].

What shapes the public's views?

Risk, benefit and trust

As elsewhere, risk and benefit perceptions are regularly highlighted in the literature as two of the main factors having a strong influence on people's attitudes towards food irradiation (e.g. Frenzen et al., 2000; He et al., 2005a; Johnson et al., 2004), while trust in government, food manufacturers and regulatory agencies is also flagged up as an important influence (e.g. Fox et al., 2001; He et al., 2005a). Very little primary evidence to support these claims is presented in the reviewed papers though.

One study which directly considers the influence of risk perceptions and trust on attitudes was carried out by Sapp (2003), who developed a theoretical model to illustrate the various influences on people's attitudes towards food irradiation[100] and tested it with questionnaires on a small convenience sample[101] in the US. His results suggested that perceived risk and sense of trust in the government and industry are key determinants of people's support for or opposition to food irradiation.

Information

As already noted, much of the existing work on food irradiation has focused on the impact of information on attitudes. As might be expected, the general conclusion is that positive information – e.g. about the benefits and safety of irradiation – leads to more positive attitudes,

[98] n= 225, non-representative sample
[99] n= 200, broadly representative sample
[100] this included factors such as trust, risk, social influences and knowledge, in addition to demographics variables
[101] n= 164, non-representative sample

and negative information – e.g. about the risks of irradiation – leads to more negative attitudes (e.g. Frenzen et al., 2000; Gunes & Tekin, 2006; Hayes et al., 2002; Rimal et al., 2004).

One of the most interesting experiments described in the reviewed literature was an experimental auction[102] carried out by Hayes et al. (2002), where participants were given a standard pork sandwich and could bid to exchange it for an irradiated pork sandwich. There were three groups of participants, each going through ten bidding rounds at the end of which the participants had to consume either the standard sandwich or the irradiated one which they could obtain through bidding. Participants were also questioned on their attitudes towards food irradiation and their perceptions of its safety. After the fifth round of bidding, one of the groups was presented with positive information about irradiation, another was presented with negative information, and the third was presented with both the positive and the negative information [note 7]. As expected, positive information led to increased bids for the irradiated pork sandwich as well as more positive attitudes towards irradiation, while negative information prompted a decrease in bids and more negative attitudes. In the group which received both types of information though, the bids also decreased and attitudes became more negative. In fact, the effect was virtually the same as that of receiving the negative information alone [note 8].

Another field experiment involved a simulated supermarket (Hashim et al., 2001) in which participants[103] were, on two occasions, asked to select a number of packages of meat – from a selection of irradiated and non-irradiated products – from a chilled cabinet. On the second occasion a poster about the safety and benefits of food irradiation was displayed on the cabinet. The presence of the poster encouraged some of the participants to switch from choosing no irradiated meat to choosing at least some, or from choosing a mixture to choosing only irradiated meat. At the same time though, some shoppers were also found to do the opposite and switch from irradiated meat to non-irradiated, with minimal net effect across the sample as to the proportion of irradiated meat being selected. The authors were unable to explain with certainty why there were such different reactions to the information displayed.

Information sources

Fox et al. (2001) pointed out that in the real world, the flow of information to the public cannot be as carefully controlled as it is in these kinds of experiments. They suggest that surveys which provide neutral or positive information about food irradiation may give results with artificially positive attitudes. Advocacy groups sending out negative messages about uncertainty and potential risks can influence public opinion (He et al., 2005a), and the public may well be more trusting of these groups than of official information sources, as illustrated by Hayes et al.'s (2002) study (described above).

There is some evidence to suggest that media attention has influenced people's views. Frenzen et al. (2000) present data on the number of news stories concerning food irradiation, and demonstrated that a decrease in people's willingness to buy irradiated food corresponded to an increase in media attention during the late 1990s [note 9].

One further interesting point is made by Gunes and Tekin (2006) whose survey of Turkish consumers[104] concluded that the public would be more positive about irradiation if well-known and trusted companies produced irradiated foods. Deliza et al. (2003), in contrast, refer to earlier work[105] carried out in 1996 which suggested that this would not be the case in the UK, and instead suggested (on the basis of work they had undertaken) that the trusted companies would risk their reputation if they chose to produce irradiated foods.

Do different types of people hold different views?

Evidence in this area is currently very patchy, with various studies coming to different conclusions about differences in attitudes between demographic groups.

[102] n= 87, no details of sample demographics given
[103] n= 207, non-representative sample
[104] n= 444, non-representative sample
[105] Data collected in 1996, details of sample not given

The weight of the evidence seems to be leaning slightly towards people in older age groups (e.g. He et al., 2005b; Rimal et al., 2004; Yeung & Morris, 2001) [note 10] and women (e.g. Frenzen et al., 2001; Rimal et al., 2004) [note 11] being more opposed to food irradiation than people in younger age groups and men. Some researchers have, however, detected no differences in attitudes between age groups (e.g. Frenzen et al., 2001; Gunes & Tekin, 2006) [note 12] or gender, or suggested that men are more opposed to food irradiation than women are (e.g. Gunes & Tekin, 2006) [note 13].

There is also some (less disputed) evidence which suggests that people with higher education qualifications (e.g. Frenzen et al., 2001; Gunes & Tekin, 2006) and people on higher incomes (e.g. Frenzen et al., 2001; He et al., 2005b; Rimal et al., 2004) have more positive attitudes towards food irradiation [note 14]. Again, however, some researchers have come to different conclusions – He et al. (2005a), for example, found evidence for more negative attitudes among the former group.

Frenzen et al. (2001) also investigated whether people at high risk of food-borne disease were more positive about irradiated foods than those at lower risk. Their survey[106] included questions about food handling practices, as well as considering old age and presence of young children in the home, all of which constitute potential risk factors. They found that these had no significant influence on people's willingness to buy irradiated foods.

Some of the reviewed research also suggests that different groups have different reasons for being opposed to food irradiation. For example, He et al. (2005a)[107] found that younger (under 40) and older (over 60) respondents were more likely justify their opposition on the grounds that irradiation was harmful and could lead to health complications, and that it damaged the environment. They also found that women were more likely than men to mention harm/ health complications.

How do views affect behaviour?

As we have seen, much of the research on behaviour with respect to irradiated food has focused on consumers' willingness to pay for and consume irradiated foods, without making the connection between attitudes and behaviour. The result is that we know a great deal about what proportion of the (US) population state that they would be willing to pay an x% premium for irradiated food [note 15], but less about what led to that decision (and what role, if any, their attitudes played). Furthermore, as a number of the authors have noted, reported willingness or intentions do not necessarily reflect actual behaviour (e.g. Johnson et al., 2004) [note 16]. Rimal et al. (2004) even suggested that intentions and actual behaviour are driven by different factors altogether [note 17].

Research typically finds that in a test setting around 50% of respondents will select irradiated food over non-irradiated food (Young, 2003), corresponding to the proportion of the population – approximately half – usually reported to have a positive attitude towards food irradiation (Frenzen et al., 2000)[108]. Johnson et al. (2004) reported some sales data on irradiated foods [note 18] and at least some of these figures reflect the 50-50 split in attitudes among the US population. None of the reviewed studies have attempted to determine whether the people with the positive attitudes are the ones buying this food though, although Frenzen et al. (2001)[109] did find that people who had previously heard of food irradiation were more willing to buy irradiated meat than those who had not [note 19].

[106] n= 10,780, not strictly representative
[107] n= 740, reasonably representative sample
[108] Although again the provision of positive information about irradiation tends to inflate this figure (Young, 2003)
[109] n=10,780, not strictly representative

The experimental auctions[110] (described above) run by Hayes et al. (2002) give some indication as to how people's views influence their behaviour: negative attitudes decreased the respondents' willingness to pay for the irradiated pork sandwich (which they would have to eat if they won it in the auction – in this case there is an argument that willingness to pay probably does reflect actual behaviour), while positive information had the opposite impact.

The material reviewed points to a number of other factors besides attitudes influencing people's decisions to purchase (or not to purchase) irradiated foods. Some of the reviewed literature draws attention to the influence of price (e.g. Frenzen et al., 2000; Johnson et al., 2004) [note 20] while other authors note that people also take into consideration the appearance of the product (e.g. Rimal et al., 2004) [note 21].

How have views changed over time?

Although a number of studies have been carried out on public attitudes to food irradiation in the US[111], there appears to be no representative time-series survey data collected using the same methodology. Some of the reviewed articles draw together data from different surveys carried out during the 1990s (which used slightly different questions) and attempt to use this information to detect trends in attitudes. One of the few things that they appear to be able to say with any confidence is that consumer awareness of food irradiation in the US has increased over time (Hashim et al., 2001) [note 22]. A number of the reviewed articles also suggest that public concern over food irradiation may have decreased, and people may have become more willing to buy irradiated food (e.g. Fox et al., 2001; Hunter, 2000; Johnson et al., 2004) [note 23] although others contradict these conclusions (e.g. Frenzen et al., 2000; Frenzen et al., 2001) [note 24].

Summary

Public attitudes towards food irradiation are fairly negative, although it appears that views vary somewhat, depending on the type of food in question, as this technology is perceived to be more appropriate for the treatment of some foods than others. The public's views are influenced by their perceptions of the risks and benefits of food irradiation, and a number of studies have demonstrated that the provision of information during the research process can affect their attitudes. Negative information appears to have a much stronger impact than positive information, and it is worth bearing in mind that outside a research setting, people could be expected to be exposed to both types of information.

While the reviewed literature seems to be leaning towards conclusions that women and people in older age groups are more opposed to food irradiation than men and people in younger age groups, and that education and income are correlated with positive attitudes, many of the survey results are contradictory so it is not possible to draw any definitive conclusions on this topic.

Very little research has been carried out on how attitudes towards irradiation influence food-related behaviour, although it does appear that those with more positive views are more willing to eat irradiated foods and vice versa. It is also unclear how views towards irradiation have changed over time – while awareness of irradiation as a food technology seems to have increased, at least in the US, it is not known whether this trend is accompanied by higher or lower levels of concern and willingness to eat foods treated in this way.

[110] n=87, no details of sample given
[111] Johnson et al. (2004) provide an extensive summary

3.5 Functional Foods

Chapter 3.5 summary | **Functional Foods**

- **People are generally sceptical or suspicious towards functional foods, although some consider them to have benefits**
- **Attitudes are not generally hostile though and the public do not consider them very risky**
- **Views on functional foods vary depending on the base product or 'carrier', the added functional ingredient, and the combination of the two (naturally occurring combinations are preferred)**
- **Belief in the effectiveness of functional foods, and experience and/or fear of disease have been linked to positive attitudes**
- **Women and older people appear to have more positive attitudes towards functional food than men or younger people**
- **Consumption of functional foods is strongly influenced by a perceived need for the product, and to a lesser extent by a belief in the health benefits**
- **Little information is available on how attitudes have changed over time**

There appears to be little available information on public attitudes towards functional foods[112] in the UK, although this may simply be a case of work not being freely available to the public - Verbeke (2005) suggests that because consumer acceptance of functional foods is of interest to the food industry, it must have carried out its own research in this area, and we also know that market reports are available to be purchased [note 1].

Much of the publicly available literature on functional foods comes from the academic domain and is based on quantitative survey work. There is some variation in terms of the robustness of the data and although we have aimed to select studies using reasonably robust methodologies, the scarcity of what is available means that in order to answer some of the research questions (and, in particular, in order to be able to say something about the state of public opinion on functional foods in the UK) we have had to rely on research which used non-representative samples. Where this is the case, it has been noted in the text.

What are the public's views on functional foods?

Authors writing about functional foods regularly point out that the literature suggests a general lack of awareness of functional foods, as well as a degree of scepticism about food manufacturers' motives and about the veracity of health claims (e.g. McConnon et al., 2004; Dean et al., 2007; Messina et al., 2008) [note 2].

Views of functional foods in the UK

Our search uncovered only two publicly available surveys focusing specifically on public attitudes towards functional foods in the UK. The results of the first of these, a survey of UK consumers aged 65+[113], reflected the scepticism described elsewhere and suggested that people in this age group did not feel that they needed functional foods (Messina et al., 2008) [note 3]. Contrary to this however, the results of the second survey[114] suggested that public attitudes towards functional foods may be more positive: when asked how likely they were to benefit them and how worried they were about the potential risks involved, the average benefit scores consistently exceeded the average worry scores for a number of different types of functional foods (McConnon et al., 2004) [note 4].

Differences in views between countries

There is evidence that attitudes towards functional foods vary between countries. A survey carried out by Messina et al. (2008) among consumers aged 65+ in Denmark, Germany, Sweden and the UK, suggests that attitudes towards functional foods in these countries – although

[112] Nutraceuticals and vitamin fortified foods were categorised by some authors as functional foods and so are included in this analysis. Note that vitamin fortified foods were not searched for separately.
[113] n= 96, recruited by snowballing
[114] n= 133, non-representative sample of the UK public

somewhat sceptical across the board – were most negative in Denmark and most positive in the UK [note 5]. Similarly, a survey in Belgium assessing the 'acceptance' of functional foods – a term not implying a positive attitude in itself – found that public attitudes were rather critical (Verbeke, 2005) [note 6].

Attitudes in North America, and, in particular, the US, appear rather more positive [note 7], although Urala and Lahteenmaki (2007) suggest, based on their literature review, that Finns have even more positive attitudes towards functional foods than do Americans.

One thing to bear in mind is that the research has been carried out at different points in time and using different (and not necessarily comparable) methodologies, including different question wording. Nevertheless, the broad difference between European and American attitudes is observed with respect to a number of novel food technologies (and commented on with specific regard to functional foods by Dean et al., 2007). It therefore seems to fit the pattern witnessed elsewhere that attitudes towards functional foods are more positive in the US than they are in Europe.

Differences in views between types of functional foods

Despite the apparently widespread scepticism towards functional foods in Europe, early focus group work in Denmark suggested that people reacted more positively to examples of specific functional foods than to the general concept (Poulsen, 1999). Further work by, for example, Dean et al. (2007) and Urala and Lahteenmaki (2007) who developed the 'functional food scale' for measuring attitudes[115], has shown that people do not perceive functional foods as a single category, but have different attitudes towards different types of functional foods [note 8].

A number of studies have been carried out investigating how people's perceptions of different types of functional foods vary. These suggest that staple foods (Dean et al., 2007) and foods with a healthy image (Landstrom et al., 2007; Siegrist et al., 2008) are the most popular 'carriers' for functional ingredients, while in terms of the health benefit, physiological health claims are preferred over psychological and cosmetic claims (Dean et al., 2007) [note 9].

These surveys also demonstrated an interaction effect between the carrier product and the specific health claim on attitudes. For example, Dean et al. (2007) found that the difference in people's perceptions of how beneficial added fibre and lowered cholesterol were, was largest when the base product was bread, and smallest when the base product was biscuits. Similarly, Siegrist et al. (2008) found that the attractiveness of their 12 tested health claims varied when applied to yogurt, but was more consistent (and consistently quite low) when applied to soup or chocolate.

Additionally, a survey in Sweden (Landstrom et al., 2007) found that positive attitudes towards functional foods may be associated with positive attitudes towards nutraceuticals. Their survey[116] found that respondents using dietary supplements or nutraceuticals were more likely to have consumed or bought at least one of the seven functional products listed in their questionnaire, in comparison to those not using either

Lastly, it has been suggested that because functional foods are a novel food category, it is likely that attitudes towards them are not yet set in stone and are still being formed. When functional foods become more familiar, it is argued that attitudes are likely to become more stable (Urala & Lahteenmaki, 2007).

[115] The functional food scale consists of a set of questions, on 7-point Likert scales, intended to measure perceptions that consumption of functional foods is personally rewarding, belief in the benefits of functional foods, belief in the safety of functional foods, confidence in functional foods, and support for functional foods.
[116] n= 972, representative of the Swedish population

What shapes the public's views?

Verbeke (2005) suggests that the only factor on which there is consensus is that people's belief in the health benefits of functional foods increases their acceptance of them. His own research supports this conclusion (Verbeke, 2006) as do a number of other studies (e.g. Landstrom et al., 2007) [note 10].

As already noted, people's attitudes towards functional foods vary depending on the carrier product, the functional component (or related health claim), and the specific combination of the two (Dean et al., 2007; Landstrom et al., 2007; Siegrist et al., 2008). It appears that this variation comes about mainly as a result of people's perceptions of specific functional foods' naturalness: the more natural the combination of product and functional ingredient appears, the more positively it is likely to be perceived (Poulsen, 1999).

The preference for 'natural' functional foods echoes the findings of McConnon et al. (2004) referenced above: their respondents were more positive about naturally occurring functional foods, believing them to be more beneficial and feeling less worried about potential risks associated with them (in comparison to probiotics, added folic acid and, in particular, plant sterols). It also helps explain why public attitudes are more positive towards foods fortified with functional components that are already present in the food – for example, fibre-enriched bread or probiotic yogurt – than towards foods with more 'artificial' functional ingredients. Dean et al. (2007) suggest that this is to do with the 'credibility' of the functional food [note 11].

Some studies also suggest that people whose family members have experienced a specific illness are more accepting of functional foods designed to mitigate against that particular illness (e.g. Henson et al, 2008) [note 12]. Studies have also suggested that susceptibility to and/or fear of disease make people more receptive to at least some functional foods (e.g. Dean et al., 2007; Herath et al., 2008). Similarly, a study in Finland[117] found that people who are interested in their health in general showed more interest in functional foods – although this effect varied between products (Urala & Lahteenmaki, 2007) [note 13].

Researchers have variously found that 'knowledge' influences people's attitudes towards functional foods, or that it has no impact (Verbeke, 2005), although 'knowledge' has been defined and measured in different ways [note 14]. They have also found that trust, and in particular trust in the food industry, influences attitudes towards functional foods (Siegrist et al., 2008). For example, Landstrom et al. (2007) note that in Finland the government has supported the promotion of functional foods, and go on to suggest that this may be part of the reason behind Finnish consumers' positive attitudes towards them [note 15].

In terms of who, as opposed to what, is capable of shaping the public's views on functional foods, the literature suggests that health professionals are the most trusted source of information on this topic [note 16]. At the same time, the media also appears to be a frequently used information source.

Do different types of people hold different views?

The bulk of the evidence suggests that the two groups of people with the most positive attitudes towards functional foods are women and those in the older age groups. Many of the reviewed articles make this point in their own literature reviews (e.g. Dean et al., 2007; Landstrom et al., 2007; Messina et al., 2008) and many, though not all, also come to the same conclusion through their primary research [note 17].

Research in Sweden suggests that this difference in attitudes appears to extend to behaviour. Landstrom et al. (2007) surveyed a broadly representative sample of the Swedish population, and found that the women in the sample had, on average, bought more functional foods than the men [note 18].

[117] n=1,113, non-representative sample

Further to the way that people's attitudes towards functional foods vary depending on the type and the functionality of the food, some of the reviewed research suggests that there are also differences between men and women in their attitudes towards particular food types. This view is supported by Dean et al's research in the UK, Finland, Italy and Germany, which found that men perceived more benefits in cholesterol-lowering foods than did women, and that women perceived more benefits in fibre-added foods than did men (2007) [note 19].

Some of the reviewed articles also suggest that attitudes towards functional foods may vary with other demographic characteristics, although there is much less agreement as to exactly which characteristics are associated with positive attitudes [note 20].

This said, a number of studies conclude that despite differences between demographic groups, demographic characteristics are not the main explanatory factors of either attitudinal differences or differences in the propensity to consume functional foods (e.g. Henson et al., 2008; Verbeke, 2006). The non-demographic characteristics such as beliefs and experiences are a better predictor of attitudes towards and propensity to consume functional foods [note 21].

Verbeke (2005), although using a non-representative sample, makes an interesting point in this respect. He notes that bivariate analysis of his data identifies a number of associations between demographic characteristics and attitudes towards functional foods, but suggests that multivariate analysis should be the preferred approach, because in reality people are "a bundle of socio-demographics with cognitive skills and affective feelings" [note 22]. A multivariate analysis of the (non-representative) sample used in this study finds that only the presence of an ill family member, a belief that functional foods have health benefits, and level of knowledge about functional foods have an influence on acceptance of functional foods, while the other correlations identified through bivariate analysis are no longer found (Verbeke, 2005). This demonstrates that the influencing factors identified in the previous section may have a stronger influence on attitudes than differences between demographic groups do.

How do views affect behaviour?

Several studies have reported "an increasing trend towards the consumption of functional foods (mainly yoghurts) in European countries" (e.g. Messina et al., 2008) and the IFIC also reported that the consumption of functional foods in the US has increased [note 23].

A number of the reviewed articles noted in their own literature reviews that a belief in the effectiveness of functional foods and a perception that consumption of functional foods is rewarding – in other words, a positive attitude towards functional foods – is associated with higher levels of consumption of these foods, or at least with higher stated intentions of consumption (e.g. Landstrom et al., 2007; Urala & Lahteenmaki, 2007; Verbeke, 2005). Similar conclusions were drawn with respect to *willingness* to buy or consume functional foods: e.g. Dean et al. (2007)[118] found that those who perceived functional foods to be beneficial were more willing to buy them than those who held the opposite view, and Urala and Lahteenmaki (2007) (who surveyed the Finnish population), concluded that a perception that the use of functional foods is personally rewarding was the best predictor of willingness to use them.

Two of the reviewed studies took this a step further and asked their respondents which functional foods they had bought from a list provided. Landstrom et al. (2007) found that those with positive attitudes towards functional foods – as measured on the 'functional food scale' developed by Urala and Lahteenmaki (2007) – were more likely to have bought a wider range of the products [note 24]. Similarly, Herath et al. (2008), in a survey which divided the Canadian population into a receptive and non-receptive segment, found that a greater proportion in the receptive segment reported consuming at least some functional foods, and a wider range of functional foods, than in the non-receptive segment [note 25].

[118] Whose survey of four European countries included a representative sample of the UK population

The study by Messina et al. (2008) of UK consumers aged 65+, however, found that with respect to intentions to buy functional foods, a *perceived need* for functional foods was a stronger explanatory factor than were attitudes. The IFIC (2002) survey of the US population similarly found that the most common reasons given by respondents for not consuming functional foods was that they did not consider themselves to be at risk of the specific disease which the functional food in question could mitigate against. These results suggest that positive attitudes towards and consumption of functional foods do not necessarily go hand in hand – someone might have a positive attitude towards them but not consume them if they feel they are not needed. Herath et al. (2008), however, note that the factors which play a significant part in shaping positive attitudes, or a 'receptivity' towards functional foods (such as health problems or concern over disease) are the same factors which give people an incentive to consume functional foods, so intuitively it is no surprise that those with positive attitudes towards functional foods are more likely to consume them.

One further point is that it has repeatedly been observed that people's willingness to consume functional foods varies between different types of foods and different functionalities (e.g. Dean et al., 2007; Henson et al., 2008; Siegrist et al., 2008). For example, Henson et al. (2008) found that their respondents' willingness to consume a lycopene-containing functional food varied depending on the carrier product. Dean et al. (2007) suggested this may be influenced by whether people expect a particular type of product to be functional [note 26]. Landstrom et al. (2007) also observed this variation in their survey, which found that the likelihood of a respondent having bought a specific functional food varied depending on their scores on particular aspects of the functional food scale [note 27].

Besides general attitudes towards functional foods and perceived need for them, a number of other factors have been shown to influence their consumption [note 28]. Taste has repeatedly been reported to be an important influencer (e.g. IFIC, 2002; Messina et al., 2008; Verbeke, 2005, 2006) but the price of the product, and convenience and appearance of the packaging have also been found to change the likelihood of consumption (e.g. Urala & Lahteenmaki, 2007; Messina et al., 2008).

How have views changed over time?

Little research has been carried out on how attitudes towards functional foods have changed over time, and no robust data are available to answer this question in the context of the UK. The two studies we are able to draw on for time series data relate to Finland and Belgium.

Urala and Lahteenmaki (2007), who carried out the Finnish study[119], found use of certain types of functional foods had increased while the use of others decreased between 2002 and 2004. They also found that the effect of perceived reward from functional food use on willingness to consume them became stronger for some products and weaker for others, generally weakening if consumption increased. At the same time, the impact of having a general interest in health on likelihood of consumption became increasingly strong, while food neophobia was found to have no impact on willingness to consume functional foods. The authors interpret these results to suggest that functional foods are becoming more familiar to Finnish consumers, to the point where they are now beginning to approach a status comparable to that of 'conventional' healthy foods.

In contrast, Verbeke's (2006) study in Belgium[120] found little change in attitudes towards functional foods between 2001 and 2004, with the exceptions that the respondents' belief in the health benefits to be obtained from functional foods had declined, and that the proportion claiming they would accept functional foods even if they tasted worse than conventional alternatives had also declined from 15.5% to 10.6%. These results suggest increasing scepticism towards functional foods, as well as an expectation that any functionality should not detract from taste [note 29]. It is not possible to determine whether the differing conclusions of the two surveys are due to differences in culture or in survey methods.

[119] in 2002 (n=1,156) and 2004 (n=1,113), with reasonably representative samples
[120] non-representative samples in 2001 and 2004

Summary

Although the public is often described as sceptical or suspicious in its attitude towards functional foods, it is apparent that people do perceive the benefits of functional foods and do not have significant concerns about potential risks. Attitudes are generally more positive than towards many other novel food technologies but the public does seem to want some reassurance that functional foods are effective and not simply a way for food manufacturers to charge more for the same products.

The public's views on functional foods do vary depending on the base product or 'carrier' in question, the specific functional ingredient added to the food, and the combination of the two – naturally occurring combinations being preferred to artificial ones.

Belief in the effectiveness of functional foods, as well as experience and/or fear of disease, have been shown to strongly influence attitudes. In addition, women and older people appear to have more positive attitudes towards them than men and younger people (in contrast to their often negative views on other novel food technologies), although beliefs and experience are better predictors of attitudes than are demographics. Similarly, although belief in health benefits does influence the consumption of functional foods, it appears that a perceived need for what a product claims to deliver has a stronger influence on likelihood of consumption.

Little information is available on how attitudes towards functional foods have changed over time, but survey data from Finland suggest that as functional foods become more familiar and their consumption increase, they begin to be seen in a similar light to more conventional healthy foods.

3.6 Synthetic biology

Chapter 3.6 summary | **Synthetic biology**

- **There is no evidence available about public attitudes to food applications of synthetic biology**
- **Other work suggests that public attitudes may be formed on a similar basis to attitudes towards other biotechnologies such as GM, although synthetic biology's focus on micro-organisms (rather than 'higher' animals) may increase acceptability**
- **Like other novel technologies, attitudes to synthetic biology are driven by broad social, political and ethical values and beliefs**

There is scant evidence regarding public attitudes to this novel technology in general, and our search revealed no research at all about public attitudes to synthetic biology for food production [note 1].

Below is a summary of the limited sources of evidence we identified that are relevant to public attitudes to synthetic biology. None is specifically about food; however, all suggest that public opinion of synthetic biology echoes attitudes towards biotechnology in general. The previous sections of this report show that food applications are generally the least acceptable applications of any types of biotechnology, and it is likely that the same would hold in the case of synthetic biology. However, taking into account the 'hierarchy of acceptability' (Gaskell, 2000), the synthesising of micro-organisms may prove to be more acceptable than the genetic modification of plants and animals and cloning. In any case, if and when food applications of synthetic biology emerge, research would be needed to ascertain how views in general translate into views about food.

What are the public's views – synthetic biology in general?

A 2008 survey in the USA revealed that 80% of respondents knew very little or nothing about synthetic biology (Mandel et al, 2008)[121]. This low level of awareness is mirrored in the UK; a Royal Society call for views on the subject in 2007 attracted just two responses from members of the public (out of a total of 22) (Royal Society, 2007).

In the US survey, 54% of respondents agreed that the benefits of synthetic biology outweigh its risks (compared to 43% who disagreed). As with other areas of biotechnology, however, the majority did not have strong views: most only mildly agreed or disagreed (as opposed to moderately or strongly). Out of the two (self selected) respondents to the Royal Society call for views, one expressed a strongly negative view, while the other recognised potential benefits but showed serious concern about how the technology would be used and managed. Such a small and biased sample cannot be taken as representative; however, these views are included here as an indicator of some of the positions that could potentially be taken by the UK public, especially those with strongly negative views.

Further light is shed on attitudes to synthetic biology by an open letter from a global coalition of non-governmental organisations to the second conference of synthetic biology in 2006 (ETC, 2006). This letter highlighted concerns that:

- society, including marginalised people, must be part of a public debate about synthetic biology, especially given the "extraordinary power and scope" of the technologies. The debate must take place internationally, nationally and locally;
- the development of synthetic biology technologies must be evaluated for their broader socioeconomic, cultural, health and environmental implications

One of the most cited papers on the social context of synthetic biology is De Vriend's (2006) *Constructing life: Early social reflections on the emerging field of synthetic biology.* According to

[121] Survey of 1,500 adults from a panel

this article, there are many similarities between synthetic biology and other biotechnologies, such as GM and animal cloning. The main risks of synthetic biology identified in this paper are reminiscent of the risks associated with biotechnologies in general:

- environmental impacts, including the interactions of synthetic organisms with naturally occurring ones;
- contamination of the natural genome pool;
- run-off risks, similar to those cited for nanotechnologies, generally referring to unintended consequences of synthetic organisms that are not engineered to have a controlled life span.

The International Risk Governance Council (2008) also flags the likelihood of the public objecting to the 'unnaturalness' of synthetic biology. The similarities with other biotechnologies suggest that public reactions to food applications of synthetic biology may be similar to reactions to other areas of biotechnology; however, research would be required to confirm whether this is the case.

Finally, Fletcher and Allen (2007) discuss the tensions at the EU governance level between promoting scientific innovation (and narrowing the gap that the USA has opened up in terms of synthetic biology development) and responding effectively to popular mistrust of science and regulators. According to the authors, the potential uses of synthetic biology in biological terrorism and warfare add a new dimension to risk-benefit analysis made by the public and European governments. The conclusion of this paper is that the precautionary principle in too extreme a form is not conducive to the EU becoming a world leader in biotechnology, which poses even more difficult challenges for building public trust in regulatory frameworks.

What shapes the public's views?

The US survey outlined above suggests that knowledge is not a prerequisite for forming a view about synthetic biology. According to the report, in terms of perceptions of risks and benefits, "there was not a significant difference between those who reported little or no knowledge and those who reported being more familiar with synthetic biology[122] (Mandel et al, 2008). This supports the social-psychological hypothesis that in situations of uncertainty and low understanding, general (top down) attitudes become more important and views are formed in alignment with those wider values[123] (see for example, Grunert et al, 2004). Indeed, the survey found that those who were less concerned than average about other sources of risk - nuclear power, global warming, genetically modified foods and mad cow disease - were also significantly less likely to see synthetic biology as more risky than beneficial [note 2].

The survey also found that cultural values had some explanatory power – a hierarchical outlook, individualism, conservatism and religiosity were all linked to higher concern about synthetic biology [note 3]. This is the reverse of what has been found for other environmental risks – e.g. global warming, nuclear power and nanotechnologies - where hierarchs (who also tend to be conservatives, religious and individualist) have been more sceptical of risks (Mandell et al, 2008). This suggests that attitudes to synthetic biology are subject to similar moral or religious concerns to attitudes towards animal cloning and GM, although these cultural drivers are more pronounced in the USA than the UK (Gaskell et al, 2006).

The negative views expressed by the two British respondents to the Royal Society call for views were driven principally by the risks to humans and the environment, but also by a mistrust of companies to ensure safety and not be driven simply by profits. A sentiment expressed by both was that we do not know enough about the long term risks to feel confident about synthetic biology [note 4].

[122] Note that this survey did not provide any information to respondents before asking them to evaluate risks and benefits.
[123] See section 3.1 for more details

Do different types of people hold different views?

In the one quantitative study that we looked at, men were found to be more likely than women to think that the benefits of synthetic biology outweighed the risks, and white people were slightly more likely to be positive than ethnic minorities (Mandel et al, 2008) [note 5]. Interestingly, this survey also found that higher levels of education correlated with more negative views.

Summary

Evidence on public attitudes to synthetic biology is extremely limited, and there is no publicly available evidence about attitudes to food applications. The available evidence suggests that public awareness and understanding of synthetic biology in general is low and that the majority of people do not have a strong initial response. In the USA, a significant proportion of survey respondents thought that the benefits outweighed the risks, although attitudes to biotechnology are generally more favourable in that country (see, for example, Hoban, 2004; Mellman Group, 2006), so this finding may not be applicable in the UK (or in other locations). Concerns about synthetic biology are similar to those expressed about other biotechnologies, including both short and long term risks to human and environmental health and the suspicion that developments are commercially driven, rather than consumer benefit driven.

Overall, the limited evidence suggests that public opinion of synthetic biology will be formed on a similar basis to opinion on other biotechnologies: as well as perceived risks and benefits to self and society, general attitudes and personal and cultural values will play a large part in opinion formation. It is important to note that food applications are generally the least acceptable applications of other biotechnologies; however, further research would be required to find out whether this was the case for synthetic biology.

3.7 Novel food processes

Chapter 3.7 summary | **Novel food processes**

- **People are rather suspicious of novel food processes, although views vary depending on the technology in question and the product it is applied to**
- **People tend to be more sceptical towards the less familiar technologies**
- **Attitudes are shaped by risk and benefit perceptions, as well as trust in the food industry and regulators, and the perceived naturalness of the resulting food product**
- **Information about the processing method and first hand experience of the finished product can alleviate concerns over the processing method**
- **Women and older people have been found to have the highest levels of concern**
- **Attitudes towards the processing method are one of a range of factors influencing food choices**
- **Virtually nothing is known about how attitudes towards novel food processes are changing over time**

The category of novel food processes covers a range of technologies, such as high pressure processing, pulsed electric fields and ohmic heating. Our literature search identified no research attempting to assess public attitudes towards novel food processes in general, but a number of studies have been carried out to investigate attitudes towards specific processes in depth – and often with respect to a specific type of food. As might be expected, different processes have received varying levels of attention from researchers (Siegrist, in press).

Most of the research in this area has been carried out in the academic sphere, and the majority of the work focuses on the US and Australian contexts, with a smaller number of studies among European consumers. The surveys have tended to use small or unrepresentative samples, and consequently much of the evidence presented on the following pages must be thought of as indicative only. The limitations of the data are noted in the text where relevant.

What are the public's views on novel food processes?

"*Historically, the food industry has had great difficulty in influencing public opinion regarding new food processing technologies. For instance, the public resisted the use of canned food products for about 50 years after the introduction of the canning process*", wrote Young (2003). It appears that this trend has continued, as the public are generally reported to be suspicious of novel food processes (Lampila & Lahteenmaki, 2007) [note 1]. Some researchers have, however, noted that if people are given an explanation of the technology and its purpose, their views tend to be more positive (e.g. Deliza et al., 2005) (although, as described elsewhere, there remains the question of how the information is presented)[note 2].

While the literature search did not uncover any studies assessing public attitudes towards novel food processes in general, work by Cardello (2003) and Cardello et al. (2007) comparing attitudes towards a number of novel processing methods suggests that people's attitudes vary depending on the specific process in question [note 3]. Research by Lampila and Lahteenmaki (2007) in Europe[124] suggests that people tend to be more positive about technologies they are most familiar with/ know the meaning of, and more suspicious of the unfamiliar.

Although the public's average level of concern seems to vary depending on the food technology in question, there is some evidence to suggest that people tend to be internally consistent. Siegrist (in press) notes that people who have negative attitudes towards one new technology are likely to be similarly negative about other new technologies and Cardello's (2003) experiment[125] found support for this: respondents who were more or less concerned than average about one technology tended to be so about a range of technologies (although their levels of concern for particular technologies did vary).

[124] n= 936, non-representative sample with respondents from the Netherlands, Belgium, Spain and Finland
[125] n= 88, non-representative

The public's views towards any particular food processing technology also vary depending on the product the technology is applied to. People can give different answers if questioned on their views about technology A, technology A applied to product X, and technology A applied to product Y (e.g. Cardello et al., 2007; Mireaux et al., 2007) [note 4].

Very little research into public attitudes towards novel food processing technologies has been carried out in the UK, but one of our identified sources focused on attitudes towards high pressure processing (HPP) in this country. This survey found that out of a representative sample of the UK population[126] 55% claimed to be willing to buy HPP foods (although the majority attached at least one condition to this – e.g. there has to be an added benefit to the product, or at least no disadvantage in comparison to a conventional alternative) while just over 30% said they would refuse to buy them altogether (Butz et al., 2003) [note 5].

What shapes the public's views?

Risk and benefit perceptions

The reviewed literature repeatedly highlights the importance of public perceptions of risks and benefits in shaping attitudes towards novel food processing technologies (e.g. Bruhn, 2008; Deliza et al., 2005; Ronteltap et al., 2007; Siegrist, in press). Cardello et al. (2007) go as far as to suggest that the perceived level of risk is the most important factor in determining people's level of interest in foods processed using novel technologies.

A number of authors argue that the reason why risk perceptions are so important in influencing public attitudes in this area is that, because the processing is carried out long before the consumer comes into contact with the foods, any risks associated with them are likely to be unobservable and so the consumer is unable to weigh up risks and benefits (e.g. Bruhn, 2008; Cardello, 2003; Ronteltap et al., 2007). In other words, the nature of the risk is such that it is outside of the control of the consumer and this generates high levels of concern [note 6a].

Siegrist (in press) suggested (on the basis of a literature review) that if a novel processing technology delivers tangible consumer benefits, it is more likely to be accepted. Work by Cardello et al. (2007)[127] found that better taste and improved nutritional quality were the benefits people were most interested in obtaining.

Siegrist (in press) notes that there is some evidence to suggest that lay people may find it difficult to assess the risks and benefits of new technologies, and that their perceptions can differ from those of the food industry and from experts. It would also appear that, in assessing risk, the public are more interested in finding out about what they consider to be the relevant implications of the technology – e.g. are the processed foods safe, and does the technology have any environmental impacts – rather than the nitty-gritty of how the process works (Lampila & Lahteenmaki, 2007).

Interestingly, although not specifically applied to novel food processes, Henson et al. (2007) suggest that perceived risk and perceived benefit tend to be negatively correlated[128], rather than being two independent concepts – so most technologies are perceived either as high-benefit and low-risk, or low-benefit and high-risk (although they do note exceptions where both risks and benefits are considered high).

Naturalness

The naturalness of the final product also appears to influence attitudes towards novel food processes. Siegrist (in press) reviews the existing literature on this issue and concludes that people tend to have confidence in foods they perceive to be natural, in contrast to the suspicious attitudes they often adopt towards foods processed using novel technologies. The results of a

[126] n= 3,000 (entire sample), including representative samples from France, Germany and the UK
[127] n= 225, non-representative
[128] n= 326, non-representative

survey[129] carried out by Cox et al. (2007) in Australia illustrate this point: they found that their respondents perceived triploidy in prawns more positively than prawns treated with electron beams or irradiation, because triploidy was considered more 'natural' than the two treatment technologies.

Trust

Trust in the food industry and regulatory bodies is also regularly flagged up as playing an important role in influencing public attitudes towards novel food processes (e.g. Bruhn, 2008; Ronteltap et al., 2007; Siegrist, in press). While the type of information transmitted to the public plays a role (Ronteltap et al., 2007) some authors have suggested that trust in the information source is more important than the accuracy of the information (e.g. Bruhn, 2008).

Experience and information

The literature on novel food processes suggests that being able to taste the resulting product reduces people's concerns about the production process, as does explanatory information about the process itself (Cardello et al., 2007). An experiment[130] by Cardello (2003) demonstrated this. Respondents were asked to rate their concern for 20 novel food processing technologies, and were then given food samples to taste which had been processed using some of these technologies, as well as an explanation of the processes. Afterwards, they rated their concern for the 20 technologies again, and the concern ratings were found to have decreased for 15 of them [note 7].

Ronteltap et al. (2007) note that the influence of knowledge and information can work in either direction, increasing or decreasing acceptance of a novel technology. Their literature review suggests that in cases where the innovation is incremental (i.e. comparable to something familiar), existing relevant knowledge increases acceptance, whereas if the innovation is radically different from existing technologies, existing knowledge needs to be supplemented by new information before it is accepted by the consumer.

Do different types of people hold different views?

Women are usually reported to be more concerned than men about a range of novel food processing technologies (Ronteltap et al., 2007). We reviewed two studies, from the US and Australia, neither of which is based on a fully representative sample but both of which come to this same conclusion [note 8]. Work by Miles et al. (2004), although focusing on food safety issues in general rather than novel processes in particular, suggests that the same pattern may apply in the UK context [note 9].

The available evidence also suggests that people in older age groups may be more concerned about these technologies than younger people. Butz et al. (2003) studied attitudes towards HPP orange juice in three European countries[131], including the UK, and found that younger people were more willing to buy the product [note 10]. Miles et al. (2004) also found[132] that people in older age groups were more concerned about technology-related food safety issues in general (e.g. pesticides, antibiotics and additives) than people in younger age groups, and this pattern may be reflected in attitudes towards processing technologies.

Little evidence is available about the effect of other demographic characteristics on attitudes, and none of this work is conclusive. Henson et al. (2007) studied attitudes towards a number of technologies, including a range of food technologies, in Canada[133] and found that highly educated people and those on higher incomes were likely to be slightly more sceptical about technology than others. In contrast, the survey by Butz et al. (2003) in Europe[134] found that those with higher qualifications were more willing to purchase HPP orange juice.

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[129] n= 453, not strictly representative
[130] n= 88, non-representative
[131] n= 3,000, representative samples in France, Germany and UK
[132] n= 1,092, quota sample similar to the UK population
[133] n= 326, non-representative
[134] n= 3,000, representative samples in France, Germany and UK

Ronteltap et al. (2007) suggest that although there is some variation in attitudes towards novel food processing technologies between socio-demographic groups, other characteristics – such as values – can better explain this variation. For example, research[135] by Lampila and Lahteenmaki (2007) found that that people with positive attitudes towards technology in general had more positive attitudes towards high pressure freezing than others, while Cardello (2003) notes that people with strong pro-environmental values tend to be more concerned about novel processing technologies, while people who trust science, government and regulatory authorities are usually more positive.

How do views affect behaviour?

When making purchase decisions, people take a number of considerations into account, besides their attitudes towards the processing technique. These include issues such as the price and taste of the food (e.g. Bruhn, 2008; Ronteltap et al., 2007; Siegrist, in press) and these considerations appear to interact with attitudes towards processing methods to result in a choice. A number of authors (e.g. Bruhn, 2008; Butz et al., 2003; Ronteltap et al., 2007) suggest that the main factor driving choices is a perception that there are personal benefits of some kind – which could be to do with cost, taste, health or a number of other issues – to be gained from selecting particular types of food.

Work by Cox et al. (2007) found that people with positive or neutral attitudes towards a technology tended to make their purchase decisions based on considerations such as price, but among those opposed to a technology their negative attitudes dominated over cost considerations and directed their food choices [note 11]. The results of a study by Lampila and Lahteenmaki (2007) also fit into this pattern: their respondents had neutral attitudes towards the processing method in question (high pressure freezing) and price was found to be the most important factor influencing their purchasing decisions [note 12].

The influence of taste on food purchasing decisions is reflected in the findings of Chern et al. (2003), who measured willingness to pay for PEF-processed (pulsed electric field) orange juice in a test auction[136]: willingness to pay was initially high (based on having seen the different types of orange juice and a description of each), but declined after participants were given some of the orange juice to taste and they found they did not like it. Although the taste of a food influences people's behavioural choices, their attitudes towards the processing method used can influence their evaluations of the taste (Siegrist, in press). An experiment[137] by Cardello (2003) demonstrated this: participants' attitudes towards processing technologies were found to influence their expectations of whether they would like a food product treated using a particular process, and this in turn was found to influence whether they actually liked its taste [note 13].

The only reviewed study which was relevant to this question and included respondents from the UK was a survey by Butz et al. (2003) on public attitudes towards HPP orange juice. The findings of this reflect the patterns identified above: in the UK, attitudes were found to be fairly negative towards HPP juice, and the majority of the respondents claimed to only be willing to consume the product if there was no additional cost or if there was an additional benefit to be obtained from consuming it [note 14].

How have views changed over time?

Very little research appears to have been carried out to track changes in the public's views over time. What little information is available does not directly address this question specifically with respect to novel food processes, although some authors comment on changes in attitudes towards food processing in general – for example, Wilcock et al. (2004) state that concern about the safety of food processing declined slightly in the US during the 1990s [note 15].

[135] n= 936, non-representative sample with respondents from the Netherlands, Belgium, Spain and Finland
[136] n= 27, non-representative
[137] n= 88, non-representative

Some of the reviewed articles note that there are food processing technologies which are now well established, despite being unfavourably received by the public when first introduced – canning, which was referred to at the start of this chapter, is one example. It is possible that public attitudes towards novel food processes will follow this pattern of increased acceptance as the processes become more familiar, but there is no evidence in the reviewed literature that this is yet happening.

Summary

The category of novel food processes covers a range of technologies, and while public attitudes vary depending on the specific technology in question, as well as the product it is applied to, in general people tend to be rather suspicious. As a rule of thumb, the less familiar a technology, the more sceptical people are about it.

Public attitudes are largely shaped by perceptions of the risks and benefits of a novel technology. The naturalness of the resulting product appears to be an important consideration, while trust in the food industry and regulators, information about processing method, and first hand experience of foods processed using these methods all serve to alleviate concerns. Although women and people in older age groups have been found to have the highest levels of concern about these processes, personality characteristics such as attitudes towards technology in general are better predictors of attitudes than demographic characteristics.

Attitudes towards novel food processes interact with other considerations such as price and taste when people make food purchasing decisions – while price, for example, may be the top priority for one person, for someone else concern over a processing method may overcome cost considerations. At the same time, attitudes towards a processing method have been shown to influence people's expectations of whether or not they will like the taste of a product processed using that method.

Virtually nothing is known about how attitudes towards novel food processes are changing over time, but historical evidence suggests that as novel processed become more familiar and less novel, attitudes towards them could become more accepting.

4 Conclusions and recommendations

4.1 Conclusions

Our conclusions are of two kinds: those that refer to what we can say about public attitudes; and those that refer to what we can say about the researching of public attitudes.

In the case of the former, we conclude:

- By and large, public attitudes are unsupportive towards the novel food technologies we have reviewed. In general, too, levels of understanding about the technologies are low.

- There is a large 'middle ground' of the undecided – there are relatively small numbers of individuals with firm views either in favour of or against any given technology.

- The middle ground is malleable – that is, the views of individuals in the middle ground are subject to change, but not in an entirely passive way.

- Key factors in determining both fixed and malleable views are: perceptions of benefit, perceptions of risk/threat and moral/ethical position. Moral and ethical concerns loom larger for some technologies than others (notably cloning and GM).

- The use of the word 'perceptions' is key: public levels of trust (in government, the media, scientists) are generally low and powerfully influence the nature of beliefs about and attitudes towards novel food technologies.

- A vital insight is the set of linkages between people's attitudes (howsoever formed), their claimed prospective behaviour, and their actual behaviour. Many studies invite respondents to indicate what they think they would do in a particular situation i.e. to claim a prospective behaviour. The evidence suggests that, in general, there are likely to be strong links between people's attitudes and the choices they *say* they will make; but a much weaker link between either of these and what they will actually do when confronted with a choice in the 'real world'.

- A key reason for this is that attitudes (towards new technologies or about ethics/morals in general) do not either exist or operate in isolation. In reality, and in particular at the point of making food choices, individuals are concerned with (for example) price, convenience, accessibility, taste, quality and so forth.

- These contextual factors are either internal or external. Internal factors consist of values, beliefs, attitudes, moral positions and so forth. These may be 'irrational', but they are real. External factors comprise economic factors, family setting, social norms and so forth.

- Of all the factors influencing public attitudes, those linked to health may be the most significant. Where new technologies are thought or believed to potentially contribute to better health they are likely to be viewed more favourably; and, conversely, where there is a perception of threat to health, they are perceived more negatively.

- It is worth bearing in mind that consumers have been making choices about 'novel food technologies' for many years. Tinned food and frozen food, for example, were novel once and took many years to achieve saturation acceptance. To this day myths persist about these 'technologies'; and even refrigeration is treated with suspicion in some communities.

- One challenging feature of 'opinion' is its relationship to 'knowledge'. The evidence is ambiguous. In some cases increased knowledge leads to more positive views, in some cases

more negative views; in some cases it leads to firmer views, in some cases to more malleable views.

- Knowledge can be both direct (through exposure to and/or experience of a new technology) or indirect (through receiving information). The latter is clearly mediated by the degree of trust in the relevant information channel (see above); the former is in part a function of the setting in which direct experience occurs (many American consumers, as we have seen, simply do not realise that they have consumed GM products).

- Levels of awareness vary between different technologies, between different groups in society and between countries.

- In summary, it is clear that there is a great deal more that needs to be found out about public attitudes (in particular, what lies behind 'top line' attitudes, and how the various drivers of behaviour interact); and it is clear, too, that engagement with the public about novel food technologies will require very careful thought and extreme tact.

In terms of the methodologies reviewed, we conclude:

- The contested nature of many of these technologies means that great pressure is placed on the research process of establishing what views are. Many of those sufficiently expert to conduct research, prepare questionnaires and undertake analysis are already persuaded of the benefits of new food technologies and appear to believe that the public are simply 'wrong' to have suspicions. Bias in questions – either actual or perceived – is an actual or prospective feature of work in this area. Those with strong views (for whatever reason) are able to deploy alleged bias (in either direction) as a reason for doubting the results from research.

- There has been insufficient attention paid to the complex underlying and contextual factors that shape public attitudes towards novel food technologies. In particular, there has been a relative shortage of high quality qualitative research.

- There is also a relative shortage of high quality time series data. Partly this is to do with the very novelty of the technologies, partly to do with inconsistent question design over time.

4.2 Recommendations

On the basis of our review and conclusions, our recommendations focus on future research needs. Issues concerning any future public engagement would, in our view, require additional review and reflection.

- We found very limited data on how attitudes towards any of the technologies we looked at had changed over time. One particular problem was changing question wording and sampling frames. To counter this, **we would recommend placing a few questions on a yearly or six-monthly tracker survey and ensuring that question wording remains unchanged.**

- There is a growing understanding that populations are not homogenous – people have different concerns and preferences and set the information they receive about new technologies in different personal contexts. **With this in mind, we feel there would be benefit in a) differentiating populations based on values and b) further examining the drivers of difference.**

- Although there has been some work which examines the effects of giving people information about the risks and benefits of particular technologies, to date there has not been very much done on how people weigh these up. **We feel that further examination of how people reach their viewpoints would further the understanding of how to communicate any**

information about novel technologies and provide insight into how people might react to, for example, health scares or particular publicity.

- Studies have repeatedly found that a large proportion of the population are undecided about novel food technologies and yet very little research as been done into the source of this indifference. **Examining the source of indifference in further detail would seem a priority.**

- Many of the studies we looked at were based on small samples from quite narrow populations and tended not to combine qualitative and quantitative research. This led some authors simply to hypothesise about the reasons for their results. **We feel there would be a great deal of merit in testing emerging findings with nationally representative populations, and combining this work with qualitative research to reach a deeper understanding of why particular results may have come about.**

- There is a lack of good qualitative work examining the links between underlying values, expressed attitudes and actual behaviours in relation to novel food technologies and yet an understanding of how these three elements interact is absolutely necessary if one is to gain a full understanding of public perceptions. **We very much feel that further qualitative work needs to be undertaken in this area.**

- Where products using novel food technologies are available to consumers, reaction has been very different to what might have been anticipated from willingness to buy studies conducted prior to product launch. We know that people tend to shop habitually, and that people react differently to different products that have been treated with the same technology. We therefore feel we would benefit from stronger research into purchasing behaviour, particularly in the European context. In order to do this, **we would recommend field experiments involving simulated purchasing with a range of products.**

- A gap in the research appeared to be the public's understanding of the role of different agents within the novel food technology arena. **In particular, the public's understanding of the role of regulators seemed under-researched, and we recommend that research in this area could support the development of any public engagement work.**

Finally, we would highlight the relationship between – on the one hand - rational, scientific, factual, evidence-based perceptions and understandings; and emotional, irrational, ethical, values-based perceptions on the other. In the context of public attitudes towards novel food technologies both perspectives are real and valid – there is no right or wrong *per se*. Any organisation seeking to pursue public engagement around novel food technologies will need to respect this reality and adopt a neutral stance.

5 Notes

5.1 Notes on overall findings

Note 1: The 'naturalness' argument is also used by supporters of GM, who sometimes argue that this technology is simply a 'natural' extension of age-old agricultural techniques such as selective breeding (see e.g. FSA, 2003).

Note 2: Research by Cardello (2003), using a non-representative sample (n=88), found that respondents' average concern 'scores' were highest for the addition of bacteriocins to food, followed by genetic modification, pulsed X-rays and irradiation. Genetic modification was, however, the most common concern among respondents, with more than 70% expressing some level of concern ('slight', 'moderate' or 'extreme') over this, while just under 70% showed some concern over bacteriocins.

Note 3: For example, the following segmentation, cited in Cormick (2007), was developed in Canada in 2000 based on 10,000 people in ten countries (USA, Mexico, Japan, India, Great Britain, Germany, China, Australia, Brazil and Canada):

- Food Elites – who prefer to eat organics and the 'best' foods and will pay for them (about 8% of the population);
- Naturalists – who prefer to buy from markets rather than supermarkets (about 16%);
- Fearful Shoppers – who have concerns about most foods – predominantly older consumers (about 28%);
- Nutrition Seekers – who treat food as fuel for the body (about 20%);
- Date Code Diligent – who read labels, but generally only look at the use by date and fat content – predominantly younger women (about 13%); and
- The Unconcerned – who don't really care too much what they eat – predominantly younger men (about 13%).

Similarly, according to Costa-Font et al (2008), populations can be segregated in three main groups regarding attitudes toward GM food, namely:

- anti-GM food or pessimistic;
- risk-tolerant or information searchers; and
- GM-accepters or optimistic.

Different compositions of such groups in a specific society determines final country acceptance of GM food.

5.2 Notes on GM food

Note 1: A review of evidence from Australia (Cormick, 2007) indicates that GM was the "smallest high concern category" compared to pesticide residues in food and food poisoning. Similarly, asking about GM food concerns relative to environmental concerns showed GM food concerns rated lower than concerns about pollution, nuclear waste, the greenhouse effect and cloning at 12% (ibid). Others studies from the USA showed that GM is less concerning than pesticide and bacterial contamination of food, and smoking and stress in general (Blaine et al, 2002; Hwang et al).

Note 2: Another demonstration of low level of awareness of GM, even in countries where it is widely available, is that only a quarter of American consumers believe they have eaten GM food, despite the presence of GM ingredients in more than half of the food available in that country (Hoban, 2004; Mellman Group, 2006; Stewart, 2005).

Note 3: There are some notable exceptions to the common public attitude of unease towards GM food. Asian consumers (Chen and Li, 2007) and consumers in developing countries (Hoban, 2007) are more likely to have positive and supportive attitudes to GM foods, probably because perceived benefits outweigh perceived risks.

Note 4: The 'menacing image propositions were:

- 'Ordinary tomatoes don't have genes but genetically modified ones do'
- 'By eating a genetically modified fruit, a person's genes could also become modified'
- 'Genetically modified animals are always bigger than ordinary ones'

Note 5: A similar picture of disengagement and scepticism emerges in Canada: the majority of respondents to one survey perceived the GM debate to be an ideological one between special interest groups, rather than a debate about consumer health and safety (Blaine et al, 2002).

Note 6: Using two different methodologies in a price auction, they find mean willingness to pay to avoid GM to be 62% and 99%.

Note 7: Up to 60% of purchasers chose the GM fruit in New Zealand, 43% in Sweden and 36% in Germany – all of which represented GM as the majority choice. In France, Belgium and the UK, the GM food was not selected by the majority.

Note 8: After hearing the following additional information, consumers were more likely to think that GM is safe: "As you may know, more than half of processed products at the grocery store are produced using some form of biotechnology or genetic modification. Knowing this, do you think genetically modified foods are basically safe or basically unsafe?" (Mellman Group, 2006)

Note 9: It was outside the scope of this project to fully explore the attitudes of other stakeholder groups. However, the evidence we reviewed contained some clues, including:

- market research in Australia suggests that Australian farmers are cautiously supportive of GM crops, as long as concerns about crop performance and consumer acceptance are addressed; and
- a 2001 poll of 250 leaders of the American food industry indicated enthusiasm about the benefits of GM (Hoban, 2004).

It is possible that the more positive attitude of some stakeholder groups indicates that, for these groups, perceived benefits outweigh perceived risks.

5.3 Notes on cloning

Note 1: "While many mentioned Dolly (the first cloned sheep), many were confused about the differences between cloned and genetically modified animals, and none focused on any specific scientific concepts or details in their initial responses." (Hallman, 2006)

Note 2: 57% of UK consumers were willing to accept animal cloning to help preserve endangered animals (subject to restrictions) and 56% thought cloning to improve the robustness of animals against diseases was acceptable, again subject to constraints (Gallup/Eurobarometer, 2008).

Similarly, in a survey of US consumers (Sosin and Richards, 2005), large majorities agreed that cloning was acceptable in certain circumstances:

- 68% said it would be acceptable "In order to improve the overall health of animals used for food—healthy animals means healthy food."
- 67% "In order to breed healthier animals that require fewer antibiotics and growth hormones."
- 64% "In order to improve the nutrition of meat and milk—for example, by breeding livestock with leaner meat."
- 64% "In order to breed animals immune to diseases like BSE, or Mad Cow Disease."
- 63% "In order to save rare animal breeds and maintain genetic diversity"
- 62% "In order to accelerate the reproduction of the healthiest and most productive livestock to improve overall animal health."

Note 3: Before participating in the workshops, the majority of respondents in the Creative Research (2008) qualitative study scored their level of concern at five out of ten, with many stating that they didn't know enough to form a view.

Note 4: "A number of qualitative studies have stressed the importance of perceived unnaturalness in trying to understand public concerns (e.g.: MacNaghten, 2001; Madsen et al., 2002; Marris et al., 2001; Wagner et al., 2001; Grove-White et al., 1997). Modern biotechnology seems to cross an invisible border between natural and unnatural. According to some of these studies, it is recognised that, for example, modern farming too is unnatural; modern biotechnology, however, adds some qualitatively new features, such as crossing barriers between species and speeding up natural processes, that make it particularly unnatural. Although none of these qualitative studies explicitly mentions, let alone addresses, the cloning of farm animals, it is likely that what makes this technology unnatural in the eyes of the public is the fact that it bypasses sexual reproduction." (Lassen, 2005)

Note 5: According to Einseidel (2005), various factors drive attitudes towards the moral status of animals, including the high profile of animal rights and animal welfare organisations, the reflections of philosophers about the nature of the soul, and the incorporation of pets as part of the family circle. See also the Nuffield Council on Bioethics (2005) for further discussion of the impact of views on human-animal relationships on attitudes to biotechnologies.

Note 6: Just 43% are morally against animal cloning in the UK, compared to 61% in the EU as a whole.

Note 7: This is in contrast to findings from a survey on attitudes to GM food, which showed that the majority of Canadians felt that, if science showed products to be safe, this should trump any ethical concerns (Blaine et al, 2002).

Note 8: 62% of UK consumers agreed that "animal cloning would risk treating animals as commodities rather than creatures with feelings" (Gallup/Eurobarometer, 2008).

Note 9: This particular concern may have its roots in the representations of cloning commonly found in popular culture. Much academic attention has focused on cloning in the popular imagination as an indicator of public perceptions. For a summary, see Maio, G (2006). *Cloning in the media and popular culture*. EMBO reports 7, 3, 241–245 (2006). Available at http://www.nature.com/embor/journal/v7/n3/full/7400652.html

See also the "Invasion of the clones," *Popular Science*, January 2005: "cloning films have racked up $1.6 billion in ticket sales since the early 1970s."

Note 10: Researchers read respondents seven informational statements about the use of animal cloning and asked whether each statement made them feel more or less comfortable with food from animals bred using reproductive cloning techniques. Respondents were most positive about information that cloned animals are like those bred using in vitro fertilization (they are born to their mothers in the usual way and grow up just like other animals). Half said they were more comfortable learning about the extent of the research, that companies that do animal cloning oppose human cloning, that cloned livestock are as healthy as other animals, and that cloning does not involve genetic modification.

Note 11: People initially rated themselves at an average of 5/10 for concern – neither concerned nor unconcerned – but by the end of the reconvened discussion group, the average was 7/10 and views were also more polarised.

Note 12: UK: Although there was no significant gender gap in levels of concern at the beginning, by the end of the 2nd workshop, the majority of women (23 out of 36) were rejecters, compared with 11 men (out of 34). Creative Research (2008)

Europe: 41% of men were likely to buy meat or milk that came from cloned animals or their offspring, compared to only 28% of women. They were also less likely to agree that animal cloning would be morally wrong (55% compared with 67%). Gallup/Eurobarometer (2008)

USA: 74% of women said they were mostly uncomfortable with using cloning techniques to reproduce animals compared with 54% of men. (Storey, 2006)

Note 13: For example, a majority of EU citizens said that it was unlikely that they would buy meat or milk from cloned animals, even if a trusted source stated that such products were safe to

eat: 20% said it was somewhat unlikely and 43% answered it was not at all likely. (In the UK this figure was 19% and 36%). Figures were very similar for the offspring of cloned animals (Gallup/Eurobarometer, 2008).

Note 14: "In 1997, only 33% of the respondents volunteered a top-of-mind response when queried what the terms “biotechnology” or “genetic engineering” brought to mind. Of this number, only 1 in 10 mentioned “cloning.” This means that of the 1,000 respondents, only 3% even made reference to cloning. In contrast, close to 80% of the respondents in the 2000 survey volunteered a response and, of this number, 14% mentioned “cloning,” with another 13% giving “cloning” as a second response."

5.4 Notes on nanotechnologies

Note 1: This study measured general support for nanotechnologies on a 10-point scale of agreement with the statement "Overall, I support the use of nanotechnology," before any information was given about what nanotechnologies were. The authors reported a resulting mean score of 5.98.

Note 2: The Macoubrie study involved a series of discussion groups across the US to explore some of the issues around nanotechnologies. It used pre and post-study questionnaires with participants to measure attitudes and how they had changed following provision of information and discussion of the issues. Results from the pre-study questionnaires showed that just 0.6% were “mostly negative” about nanotechnologies, while 20.9% were either “mostly” or “quite positive” about them. The majority, however, were either neutral (37.9%) or responded “don’t know” (40.7%). Following the study, while the proportion responding “don’t know” had fallen to just 2.8%, and 49.7% were “mostly” or “quite positive”, 32.2% remained “neutral”, while a further 9.6% said they were “mostly negative” about the technologies.

Note 3: Some of the key recommendations emerging from 10 sessions of hearing evidence and deliberating showed support for further development of the technologies. In particular, those recommendations were:

- "Government should support those nanotechnologies that bring jobs to the UK by investment in education, training and research";
- "The government should set up partnerships with nations leading in those technologies that can improve health";
- "There should be LESS ethical controls and red tape" - "Such controls lead to the strangulation of inventiveness and reduce job creation, allowing other countries to steal a march on us. Development of new technologies create jobs through trickle down of wealth created".

There was strong support from the jury for all but the last of these recommendations.

Note 4: Respondents were provided with the following information in the questionnaire (which covered the use of biotechnology and nanotechnologies in medicine, farming and food):

At the start of the questionnaire, information was provided on nanotechnologies:

> *What is nanotechnology? You may not have heard of nanotechnology. Nanotechnology is a new development in science that involves the use of materials of an extremely small size, often less than a billionth of a metre. At this scale specialised instruments are being used to construct new materials often called nanoparticles. Overseas, nanoparticles have been used to develop clothing with stain-resistant fibres and formulate more effective sun-screen lotions. Nanoparticles are also helping to deliver drugs to targeted tissues within the body affected by cancer. Nanoparticles are also being used the automotive industry, and in electronics, computers and communication. As these examples show nanoparticles can be useful. However, scientists have also found that some particles can*

be poisonous or toxic. This has led to calls to avoid the possibility of nanoparticles becoming hazardous to people or the environment.

Later, when the questionnaire turned to the use of nanotechnologies in food, the following information was provided:

GM has been used in New Zealand to modify the cells of animals and plants by using genetic material from other plants or animals. With the development of nanotechnology a possible new method uses nanoparticles to penetrate the wall of a cell and enable the genetic material within the cell to be rearranged. The new method would avoid using genetic material from other plants or animals because it would only alter the genetic material within the cell. Using the new method it could be possible to raise farm animals that would produce lamb or beef with 20 per cent less cholesterol-causing fat.

Note 5: One particular discussion, highlighted in the report, best illustrated this lack of enthusiasm:

"-I think in medicine it's great. But I think it's a bit wary when you come down to food and what have you, trying to enhance that.
-Why does food need engineering?
-Yeah. What is the benefit of that?
-We can live without any of that."

Note 6: It could be, however, that this represents a lack of awareness of the potential for nanotechnologies in food, rather than a lack of enthusiasm – particularly given that 7% of the total risks mentioned for nanotechnologies applications in a subsequent question were related to food.

Note 7: A previous study, also by Siegrist (2007), also found that the use of nanotechnologies in packaging was seen as more beneficial than in foods, however, it that study it was actually rated as of higher risk than in either juice or bread.

Note 8: Kahan et al. add that this can be interpreted in one of two ways – either that exposure to information about nanotechnologies makes people more positive about them, or, more likely according to the authors, that those who are most likely to be interested in finding out about the technologies tend to be more disposed towards supporting them (see also Priest, 2006).

Note 9: When presented with a specific scenario about using nanotechnologies for land remediation, comments included: "Will there by any unanticipated effects?"; "Would the fact that it's a quicker process mean that safety issues may be overlooked?"; "What's happening to them? Because we don't know how it breaks down, if it breaks down, whatever" (Stilgoe, 2007).

Note 10: They found that 53% of their US respondents believed the benefits of nanotechnologies would either slightly or strongly outweigh the risks while 36% only believed the opposite.

Note 11: In this study, benefit vs risk perceptions were measured by subtracting overall ratings for benefit perceptions from overall ratings for risk perceptions, which were, in turn, each measured on an additive index of agreement (out of 10) with four statements. A mean score of -7.54 showed that in general benefits were seen as outweighing risks.

Note 12: Results from Macoubrie's (2005) end-of-study survey of participants who had taken part in discussion group sessions also supported the idea that, despite real concern about 'unknown' risks, potential long-term health risks, the potential effects of 'messing with nature' and 'playing god', overall 41% of respondents said that they believed the benefits outweighed the risks – only 15% felt the opposite.

Note 13: In the qualitative workshops, while a number of concerns were raised, there was also much enthusiasm about potential benefits, such as medical applications, the possible creation of new materials that would create less waste, and the unknown potential for nanotechnologies to benefit both individuals and humankind as a whole.

Note 14: e.g. "the animals used to make this product may suffer unforeseen health problems" (agreement = 54%); "there is a risk that use of modified animals will result in contamination of farm land" (agreement = 43.4%) vs. "consuming this product would improve the health of New Zealanders" (agreement =30.3%) and "this product will result in increased overseas demand for New Zealand lamb and beef" (agreement =27%).

Note 15: They found that the higher the perceived risks, the higher the perceived benefits.

Note 16: Lee et al (2005) concluded that *"trust in scientists seems to be a better predictor of general support for nanotechnology than science knowledge".*

Note 17: This was highlighted by the following conversation between participants:

> *- "I would assume that before it came to the market, whatever product, it would have been properly tested."*
> *- "Surely something like thalidomide was thoroughly tested and look what it did. You know, it was going to be revolutionary, safe and everything and look what it did."*
> *- "Valid point."*
> *- "It has to be tested for a few generations just to see the impact, 30 years or so."*
> *- "So can we trust them? Obviously not."*

Note 18: This was demonstrated by comments highlighted in the report:

> *"I think what concerns me is the drive of all this. You're going to create better tasting dessert. There's nothing better than apples, right? Apples are great. They grow. They're natural. I mean all the stuff that we need is already here. What is the point of this? Why are we being driven always away from just the natural free things that grow, you breathe, to things that you have to pay for? ... It's all about just markets."*

Note 19: In the survey conducted for this study, a segmentation model divided participants into five groups based on their attitudes towards technological innovations. These were:

- 'true believers' - uniformly supportive of emerging science and technology);
- 'utilitarians' – expect experts to base decisions about policy on evaluations of risks and benefits
- 'moral authoritarians' – prefer to defer to 'ethical leadership' on these issues
- 'ethical populists' – believe ordinary people should make decisions for themselves based on ethical considerations; and
- 'democratic pragmatists' – similar to 'ethical populists' only they believe decisions should be based on risk-benefit considerations.

The survey found that general support for nanotechnologies was the highest amongst 'true believers' (91%), followed by 'utilitarians' (81.5%). Support was lowest amongst 'ethical populists' (73.4%) and 'moral authoritarians' (74.7%).

The study suggested that around a third of the US population could be considered 'true believers', compared to a quarter of Canadians, however, there was no indication of what the breakdown of the UK or European population might be according to this model.

Note 20: Kahan et al. describe these axes as follows:

> "The first, 'hierarchy-egalitarianism', characterizes the relative preference of persons for a society in which resources, opportunities, privileges and duties are distributed along

fixed and differentiated lines (of gender, race, religion, and class, for example) versus one in which those goods are distributed without regard to such differences. The other, 'individualism-communitarianism', characterizes the relative preferences of persons for a society in which individuals secure the conditions for their own flourishing without collective interference versus one in which the collective is charged with securing its members' basic needs and in which individual interests are subordinated to collective ones."

Note 21: In order to assess the effect of information, respondents were divided into two groups. One group was exposed to no information about nanotechnologies aside from the minimal introductory statement. The second group received two paragraphs of additional information (the order of which was randomly varied) relating, respectively, to the benefits and risks of nanotechnologies:

"The potential benefits of nanotechnology include the use of nanomaterials in products to make them stronger, lighter and more effective. Some examples are food containers that kill bacteria, stain-resistant clothing, high performance sporting goods, faster, smaller computers, and more effective skincare products and sunscreens. Nanotechnology also has the potential to provide new and better ways to treat disease, clean up the environment, enhance national security, and provide cheaper energy.

While there has not been conclusive research on the potential risks of nanotechnology, there are concerns that some of the same properties that make nanomaterials useful might make them harmful. It is thought that some nanomaterials may be harmful to humans if they are breathed in and might cause harm to the environment. There are also concerns that invisible, nanotechnology-based monitoring devices could pose a threat to national security and personal privacy."

Benefit versus risk was measured on a four point scale where 1 = the risks of nanotechnology will greatly outweigh its benefits; 2 = the risks of nanotechnology will slightly outweigh its benefits; 3 = the benefits of nanotechnology will slightly outweigh its risks; and 4 = the benefits of nanotechnology will greatly outweigh its risks. Average ratings for those who received minimal information, compared to those who received more detailed information are shown in the table below:

	Minimal info	Detailed info
Hierarchs	2.64	2.72
Egalitarians	2.67	2.58
Individualists	2.62	2.73
Communitarians	2.70	2.54

Note 22: participants were subject to the same arguments as in the 2007 study, but this time the arguments were ascribed to particular advocates, described as "policy experts at universities" and shown with photos and info (e.g. on their publications) to highlight their particular values and cultural worldview.

Note 23: Each of 19 applications for nanotechnologies was rated on a 5-point scale for a range of feelings. Those related to affect were: "feelings related to each application" (1 = positive; 5 = negative) and "worries related to each application" (1 = not worried at all; 5 = very worried).

Note 24: This study suggested that negative emotions towards nanotechnologies and science in general, or negative affective responses correlated to lower support for nanotech in general and a higher level of risk perceptions (relative to benefits).

Note 25: 40% of men and 19% of women said they had heard of nanotechnology; awareness amongst ABs was 42% falling to 16% amongst DEs; 20% of those over 55 had heard of it as opposed to a third of under 55s.

Note 26: Siegrist et al. found that while age did not affect risk perceptions of nanotechnologies' use in food and packaging, nor benefit perceptions of nanotechnologies' applications in food, older people did tend to perceive nanotechnologies in packaging as significantly more beneficial than younger respondents.

Note 27: Negative emotion toward science in general was measured on a 10 point scale by asking respondents whether they feared the potential effects of scientific research. Negative emotion toward nanotechnologies was measured by asking respondents on a 10 point scale whether they were worried about nanotechnology. General support was measured through a 10 point scale of agreement with the statement *"Overall, I support the use of nanotechnology"*. Perceptions of risks versus benefits was measured by subtracting benefit perceptions from risk perceptions: risk perceptions were measured on an additive index of four 10-point items measuring agreement with the statements:

- *"Because of nanotechnology, we may lose more U.S. jobs;"*
- *"Nanotechnology may lead to an arms race between the U.S. and other countries;"*
- *"Nanotechnology may lead to the loss of personal privacy because of tiny new surveillance devices;" and*
- *"Nanotechnology may lead to the uncontrollable spread of very tiny self-replicating robots."*

Benefit perceptions were measured on a similar additive 10-point scale of agreement for the following four statements:

- *"Nanotechnology may lead to new and better ways to treat and detect human diseases,"*
- *"Nanotechnology may help us develop increased national security and defensive capabilities,"*
- *"Nanotechnology may lead to new and better ways to clean up the environment," and*
- *"Nanotechnology may give scientists the ability to improve human physical and mental abilities*"

Knowledge about science in general was measured on an additive index of seven dichotomous items asking respondents whether (1) lasers work by focusing sound waves; (2) the center of the earth is very hot; (3) antibiotics kill viruses as well as bacteria; (4) electrons are smaller than atoms; (5) all radioactivity is man-made; (6) which travels faster: light or sound?; and (7) the earth goes around the sun or the sun around the earth?

Knowledge about nanotechnologies was measured on an additive index of six dichotomous items asking respondents whether (1) nanotechnology involves materials that are not visible to the naked eye; (2) U.S. corporations are not using nanotechnology yet to make products sold today; (3) experts consider nanotechnology to be the next industrial revolution of the U.S. economy; (4) a nanometer is a billionth of a meter; (5) nanotechnology allows scientists to arrange molecules in a way that does not occur in nature; and (6) a nanometer is about the same size as an atom.

Note 28: In the Kahan et al. study, benefit versus risk was measured on a four point scale where 1= the risks of nanotechnology will greatly outweigh its benefits; 2 = the risks of nanotechnology will slightly outweigh its benefits; 3 = the benefits of nanotechnology will slightly outweigh its risks; and 4 = the benefits of nanotechnology will greatly outweigh its risks.

The mean score for men was 2.81 compared with 2.5 for women (mean 2.5). The mean score for whites was 2.67 compared with 2.32 for African-Americans (2.32). Amongst those who received a greater level of information about nanotechnologies, the mean scores were 2.76 for whites and 2.02 for African-Americans.

Note 29: Willingness to buy (WTB) was measured for each item on a 5 point scale of agreement with the statement "I would buy nano-bread/juice/tomatoes/packaging", from 1 = not at all, to 5 = absolutely. Mean scores for each product are shown in the table below:

	Mean WTB
Packaging	2.88
Juice	2.59
Bread	2.47
Tomatoes	2.42

5.5 Notes on irradiation

Note 1: Frenzen et al. (2001) carried out one of these surveys in the US (n=10,780, but not a strictly representative sample of the population) and found that, as it happened, 50% of the sample were prepared to buy irradiated foods. He et al. (2005b) obtained similar figures in their survey, also in the US (n=740, a reasonably representative sample, although vegetarians were excluded because the research focused specifically on irradiated beef; in addition, the data were collected in 1997-98), finding that 55% of respondents would buy irradiated beef at the current market price for non-irradiated beef, 31% would not buy it, and 14% were unsure. Their results also showed that 56% of respondents thought irradiation was necessary and 25% thought it was unnecessary, while 19% were either indifferent or unsure. (They also note that there appears to be some confusion among the public as to exactly what their views are on irradiation – of those who said they would not buy irradiated beef, 39% also said they thought irradiation was necessary.)

Note 2: Of the 50 respondents, 44% felt that irradiation is necessary for fruit, 38% for vegetables, 12% for seafoods, 6% for poultry and 4% each for pork and beef; 59% thought irradiation was not necessary for poultry, 58% for pork, 52% for seafoods, 51% for beef products, 20% vegetables and 16% fruit. (The remaining respondents within each food type category thought that irradiation was "somewhat necessary".)

Note 3: Other, less common reasons were: irradiation doesn't make food safer (4.2%), respondent not eating meat or poultry (4.0%), concern over the environmental impact of irradiation (3.9%), not needing irradiation to make food safe (3.5%), not liking trying new food or products (3.3%), price of irradiated food (2.5%), taste or appearance of irradiated food (1.4%), and other unspecified reasons (10.2%). In addition, 7.9% of respondents weren't sure of their reasons while 1.4% refused to answer.

Note 4: Of their nationally representative sample, of the 31% of their respondents who refused to buy irradiated beef, 66% stated that they were not sure whether it was safe. Around 23% thought that irradiation was harmful and would lead to health complications, while 4% thought it posed occupational hazards, and 3% selected environmental pollution as a reason for rejecting it. About 13% had other reasons not listed in the survey.

Note 5: The degree to which respondents were worried that they could suffer ill health as a result of food irradiation was measured on a 5-point scale (where 1 is not at all worried and 5 is very worried). The mean score across the sample was 2.41, while 54.3% of respondents selected either 1 or 2, and 18.1% selected 4 or 5. The degree to which respondents thought this was likely was measured on a similar 5-point scale (where 1 is very unlikely and 5 is very likely), and in this case 57.5% of respondents selected 1 or 2, while 19.7% selected 4 or 5.

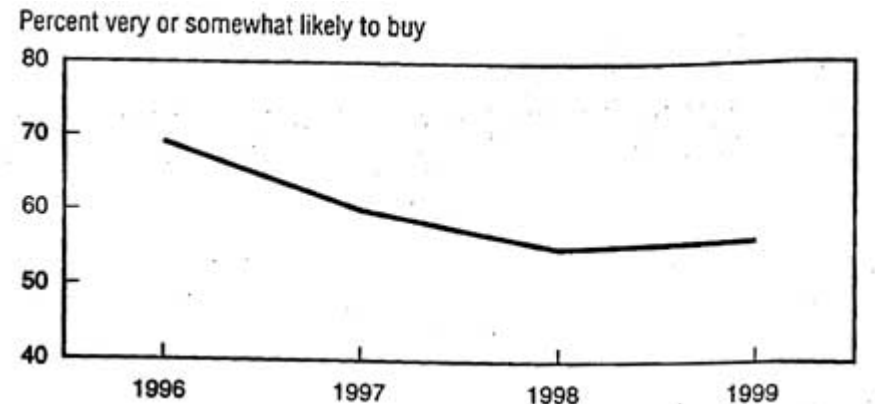
Note 6: Only Johnson et al. (2004) in the US and Gunes & Tekin (2006) in Turkey have attempted to assess public attitudes to food irradiation within a wider context of food safety issues. While both of these studies find that food irradiation is a secondary concern, after a wide

range of issues including pesticides, animal drug residues, additives, hormones, bacteria and toxins, neither has obtained a robust enough sample to draw definitive conclusions.

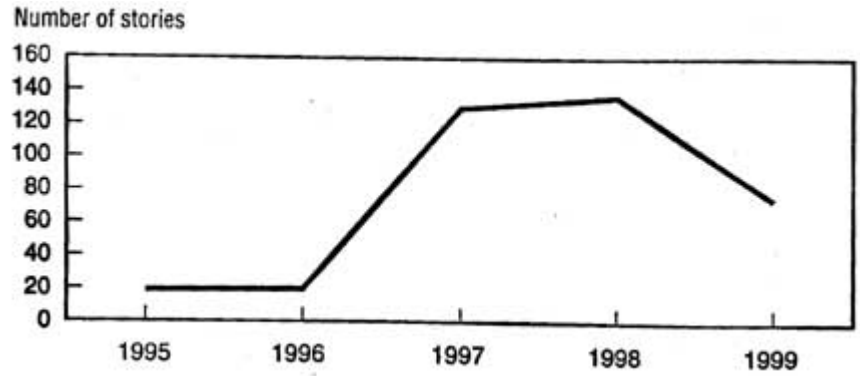
Note 7: The following excerpt from the article describes the experimental auction process in more detail: "Subjects were informed that they had each been endowed with a typical pork sandwich (Type I), and that an irradiated (Type II) pork sandwich would be sold using a second-price, sealed-bid auction in which the highest bidder wins and pays the second highest bid (Vickrey). The auction had ten rounds (or trials) of bidding, each with equal probability of being binding. In each trial, the monitor publicly displayed the identification number of the highest bidder and three bids: the second highest, average, and lowest bid. Subjects were informed that in order to complete the experiment and earn their participation fee they would have to consume, at the conclusion of the experiment, either: a) the typical pork sandwich which they had been given, or b) the irradiated pork sandwich which was available for purchase in the auction." (Hayes et al., 2002).

Note 8: The authors note that the negative information in the experiment was identified as having originated from a consumer advocacy group, while the positive information was identified as originating from the American Council on Science and Health (a consumer education association) – which raises some interesting questions about public trust.

Note 9: Frenzen et al. (2000) present data on the proportion of shoppers in the US who are likely to buy irradiated foods, and find that this declined during the late 1990s, as the number of media stories about food irradiation increased.



Proportion of supermarket shoppers very likely to buy irradiated food.



Number of TV and newspaper stories about food irradiation 1995-1999.

Source: Frenzen et al. (2000)

Note 10: He et al. (2005b) surveyed a random sample of the US population (n=740) and developed two models on the basis of the collected data. These were termed the 'inclusive' model (n=638), including all complete questionnaires, and the 'exclusive' model (n=458), including only

those complete questionnaires with no inconsistencies in the answers (i.e. excluding anyone who gave inconsistent responses, such as agreeing that a product labelled as irradiated should be avoided, and also agreeing that beef irradiation is necessary). In both models, older respondents were found to be more resistant to food irradiation. Rimal et al. (2004) carried out a simulated supermarket experiment, at the end of which they asked the participants (n= 207, non-representative sample) whether they intended to buy irradiated foods in the future, and found that older people were less likely than young people to say they would.

Note 11: Frenzen et al. (2001) carried out an extensive (n=10,780, not strictly representative) telephone survey in the US, and found that women were less willing than men to buy irradiated foods – 45.4% compared to 54.1%. Rimal et al.'s (2004) survey (n= 207, non-representative) at the end of their simulated supermarket experiment also found that women were less likely than men to report an intention to buy irradiated food in the future.

Note 12: Gunes and Tekin (2006) surveyed a (non-representative) sample of 444 Turkish consumers, and found no differences in attitudes between age groups.

Note 13: The survey by Gunes and Tekin (2006) in Turkey (n=444, non-representative) also found that 63% of women, compared to 59% of men, were willing to buy irradiated foods (although these figures are based on having heard a positive statement about food irradiation and its benefits).

Note 14: The results of Frenzen et al.'s (2001) survey (n=10,780, not strictly representative) suggest that those with at least some college education (53.2% compared to 44.2% of those educated to high school or lower level) and those with incomes of at least $30,000 (56.4% compared to 45.5% those on lower incomes) were willing to buy irradiated meat or poultry. (They do, however, point out that a large proportion of respondents refused to answer the question on income, which could have influenced the results.)

Note 15: For example, He et al. (2005a) found that, out of their sample of 740 US consumers (representative of the wider population) 51% indicated a willingness to consume irradiated beef at the current market price for non-irradiated beef, and out of those a further 60% were willing to pay a further additional premium for it, while 32% were not and 8% were unsure. Gunes and Tekin (2006) found that, out of their sample of 444 Turkish consumers (non-representative sample) 44% were willing to consume irradiated food at the current market price for non-irradiated food. In addition, they found that 23% were willing to pay a 5% premium for irradiated food, while 19% were willing to buy it at a 5% discount, and 12% would *only* buy it at a 5% discount. (They suggest that the reason for these low percentages may be that people perceive lower prices to equate to lower quality.)

Note 16: Johnson et al. (2004) describe a survey where 44% of respondents said they intended to buy irradiated food, but of those only 27% did, while of the 16% who said they would not buy irradiated food, 5% did.

Note 17: Rimal et al. (2004) found that their respondents' (n=207, non-representative) purchase intentions were influenced by their knowledge about food safety and by their socio-demographic characteristics, while their actual purchase decisions were influenced by the attributed of the food products – for example, information on the package and the appearance of the product.

Note 18: Johnson et al. (2004) report on sales of irradiated foods at a Florida market in 1992, where 57% of strawberries sold in January were irradiated and 43% were non-irradiated. In contrast, they also note that in Chicago in 1992, around 90% of strawberries, grapefruit and oranges sold were irradiated and only 10% non-irradiated.

Note 19: A telephone survey of 10,780 people (not nationally representative) showed that of those who had previously heard about food irradiation, 53.6% claimed to be willing to buy irradiated food, compared to 45.9% of those who had not heard about it (Frenzen et al., 2001).

Note 20: A survey of US consumers (n=50, non-representative) by Johnson et al. (2004), for example, suggested that although some people may be willing to pay more for irradiated food, few would be willing to pay more than a 5% premium, while others may be more inclined to buy irradiated foods at a discount. Frenzen et al. (2000) describe a study where irradiated chicken breasts were sold at the same price as non-irradiated chicken, and their share of sales was 43%, but when a 10% premium was introduced, their share of sales dropped to just 19%.

Note 21: Rimal et al. (2004) carried out a simulated supermarket experiment, where participants were asked to select packages of meat from a chilled cabinet, after which they were asked to explain the reasons for their selection, and some of the participants stated that they had considered the appearance of the meat in making their decision.

Note 22: The literature review in this article recounts that in 1984, 23% of consumers were found to have heard of irradiation, by 1986 this figure had risen to 66%, and by 1995 to 72% (Hashim et al., 2001).

Note 23: Johnson et al. (2004) surveyed a non-representative sample of US consumers in Atlanta (n=50) and compared the respondents' attitudes to a postal survey they had carried out in 1993 (n=446). The respondents were asked to indicate, on a 5 point scale (where 1 = not concerned, 3 = somewhat concerned and 5 = extremely concerned) how concerned they felt about food irradiation. In 1993, the mean response was 2.8, and by 2003 it had declined to 2.4. Hunter (2000) suggests, based on reviews of survey data, that the proportion of people willing to buy irradiated food increased from around 45-55% in the early-to-mid 1990s to 80% in 1998. (The 1998 survey may provide an example of the kind of survey question which strongly influences people's responses: they were asked how likely they would be to buy food labelled 'irradiated to kill harmful bacteria'.)

Note 24: Frenzen et al. (2001) report that a 1993 survey in the US found that over 60% of adults were extremely concerned that irradiated foods might be radioactive or capable of causing cancer or birth defects; while a 1997 survey found that 69% of supermarket shoppers believed that irradiated foods posed a health risk. Frenzen et al. (2000) refer to surveys which found that in 1996, 70% of people were willing to buy irradiated food, but by 1999 this figure had decreased to less than 60%.

5.6 Notes on functional foods

Note 1: The most up-to-date and comprehensive report on UK consumer attitudes to functional foods that our search identified was a report published by Mintel in March 2008 (Available from: http://oxygen.mintel.com/sinatra/oxygen/search_results/show&/display/id=227687). At £1,500 however, it was beyond the budget of this review.

Note 2: Consumers have, for example, raised concerns that the concept of 'functional foods' could be used as a marketing tactic and as a way to increase prices (Messina et al., 2008). Meanwhile, Verbeke (2005) suggested that functional foods which taste the same as their conventional counterparts may not be perceived as trustworthy, and that people may have more confidence in the health claims of functional foods when they taste worse than conventional alternatives.

Note 3: They were asked the question "To what extent do you feel that you need to buy foods with added health benefits in the next month?" with answer options on a scale from 1 to 5 (where 1 = definitely don't need to and 5 = definitely need to). The average score across the sample was just below the half-way point at 2.92.

Note 4: The fieldwork was carried out between late 2000 and early 2001. Average scores are below.

	Plant sterols	Probiotics	Folic acid	Naturally occurring functional foods
Average benefit score (scale 1-5)	3.01	3.11	3.37	4.34
Average worry score (scale 1-5)	1.60	1.52	1.35	1.14

Benefit scores: 1 = not likely and 5 = extremely likely
Worry scores: 1 = not worried and 5 = extremely worried

This survey also confirmed that understanding of functional foods is fairly low. The respondents were asked to score their level of understanding about functional foods on a scale from 1-5 (where 1 indicated knowing nothing and 5 indicated knowing everything). The average scores ranged around 2 for the added functional ingredients (1.94 for plant sterols, 2.08 for probiotics and 2.39 for added folic acid) but rose to 3.10 for naturally occurring functional foods.

Note 5: On a scale from 1 to 5 (where 1 = definitely don't need to and 5 = definitely need to) the average scores in answer to the question "To what extent do you feel that you need to buy foods with added health benefits in the next month?" were 1.89 in Denmark, 2.36 in Germany and 2.56 in Sweden, compared to 2.92 in the UK (Messina et al., 2008).

Note 6: Only 46.5% of the sample (which was non-representative; n = 215) claimed to 'accept' the concept.

Note 7: A representative survey of the Canadian population (n = 1,735) found that 47% were 'highly receptive' to functional foods and nutraceuticals, while 53% were relatively unreceptive (Herath et al., 2008). In the US, a telephone survey in 2002 by the International Food Information Council, covering a representative sample of the US population, found that 93% of the population believe some foods to have health benefits that "go beyond basic nutrition" (i.e. to be functional) and 85% of the sample were interested in learning more about these foods (IFIC, 2002), while a more recent web survey found that more than 80% of the population claimed to be either currently consuming or interested in consuming functional foods or beverages (IFIC, 2008).

Note 8: In other words, instead of having an attitude towards functional foods, an individual may have one attitude towards a probiotic yogurt, a different attitude towards a cholesterol-lowering spread, and yet another towards a fibre-enriched bread.

Note 9: For example, Dean et al. (2007) carried out a survey in four European countries (n=2,094 with representative samples in the UK, Italy, Finland and Germany), comparing people's preferences for fibre-enriched and cholesterol-lowering bread, pasta and biscuits, and discovered that functional bread and pasta – i.e. the staples – were preferred over functional biscuits. Respondents were asked to rate their agreement with the following statements (on a seven-point scale where 1 = strongly disagree and 7 = strongly agree): "Eating cholesterol-lowering bread/pasta/biscuit would be beneficial to me" and "Eating bread/pasta/biscuits containing added fibre would be beneficial to me". The mean scores were 5.10 for bread, 4.82 for pasta and 4.48 for biscuits.

Note 10: For example, in a sample of Belgian consumers, belief in health benefits was found to correlate with acceptance of functional foods (Verbeke, 2005 using a non-representative sample of n=215 Belgian consumers). Similarly, Urala and Lahteenmaki (2007) found a perception that consuming functional foods is rewarding to be the strongest predictor of willingness to consume them (the study was conducted using a reasonably representative sample of the Finnish population n=1,113).

Note 11: Dean et al. (2007) suggest that this is to do with the 'credibility' of the functional food, whereby combinations occurring naturally are credible and are therefore more likely to be viewed positively than combinations which are perceived as unnatural.

Note 12: Henson et al investigated this in Canada (n=268, non-representative sample) with regard to the incidence of prostate cancer and propensity to consume two lycopene-containing functional foods and one nutraceutical, and found a positive relationship between the presence of prostate cancer in the family and the propensity to consume one of the functional foods.

Note 13: In this study, it was found to be the strongest for cholesterol-lowering spread.

Note 14: For example, a study in Belgium by Verbeke (2005) found that knowledge about functional foods, measured by agreement with the statements ''I know foods with specific beneficial health impact'', ''I know enriched foods'' and the question ''How do you judge your personal knowledge of functional foods?'' all on 7-point scales, was not associated with acceptance of functional foods. In contrast, a study in Canada by Henson et al. (2008) found that people with specialist knowledge about health or nutrition (measured by the question 'Do you have expertise related to medicine, nutrition, health care or are you employed in the food or nutrition industry?') were less likely to purchase the functional foods they investigated, i.e. ones containing lycopene – whether the same is true for other functional foods is uncertain.

Note 15: Although the issue of who we trust is not necessarily a straightforward one. McConnon et al. (2004) found that their sample of UK respondents felt it to be the food manufacturers' and government's responsibility to keep them informed about functional foods for example, but also displayed a lack of trust in these institutions. (The study used a non-representative sample of n=331).

Note 16: The IFIC (2002) survey of the US public found that 34% considered physicians and 21% nutritionists or dieticians to be the most reliable source of information about the health benefits of different foods. Similarly, McConnon et al. (2004) note that "consumers typically regard nutritionists as impartial and trustworthy". The IFIC survey also found that more than a fifth of the respondents stated that they obtain information about functional foods from the media.

Note 17: For example, a recent IFIC survey of the US population found that men showed much less interest in functional foods than women did, while the age group most likely to be consuming functional foods were the 55-64 year-olds (IFIC, 2008).

A survey in Canada (Herath et al., 2008; representative sample) also found that older people were more receptive towards functional foods than younger people, possibly because of the link between concerns over disease – which may be more prominent in this age group – and interest in functional foods, also identified in their study.

In a survey of a broadly representative sample of the Finnish population, Urala and Lahteenmaki (2007) found that older people perceived the use of functional foods to be more rewarding than did younger people, although they note that this difference was relatively small: less than a point on a 7-point scale.

A representative survey of the Swiss population by Siegrist et al. (2008) found that older people were more inclined to buy functional foods than were young people, and the survey in Sweden by Landstrom et al. (2007) similarly found that older respondents were more likely to have bought juice with extra vitamins and minerals than the youngest age group (17-24 years).

A survey in Canada by Henson et al. (2008), though not representative of the wider population, suggested that the variation in attitudes towards functional foods between age groups did not apply uniformly to all functional foods, but varied between product types.

Note 18: The survey included a list of seven functional food products, and of a sample of 972 respondents (of whom 47% were male and 53% female). The average number of products bought by a female respondent was 2.63, while the average number bought by a male respondent was only 2.1. More males than females had not bought any of the listed products, and female respondents were more likely than males to have bought probiotic fruit drinks and milk products, as well as fibre-rich bread.

Note 19: Although they interpret this to mean that men may see more benefits in specific health claims and women in general health claims, the number of functional foods covered by the survey is too small to make definite generalisations. It is fairly conclusive, however, in showing that men and women have different attitudes towards different functional foods, and men are not always necessarily the more negative.

Note 20: For example, both the IFIC (2008) survey of the US population and the survey of the Swedish population by Landstrom et al. (2007) found that respondents with higher education qualifications were more likely to consume functional foods. In contrast, the survey of a representative sample of the Canadian population, carried out by Herath et al. (2008) suggested that those with higher qualifications were more likely to be unreceptive to functional foods: their 'unreceptive' cluster included 45.7% of people with graduate or postgraduate degrees, compared to 33.4% in the cluster described as 'highly receptive to functional foods'. Their analysis also suggested that the people who were more receptive to functional foods we more likely to have lower incomes and to live in rural areas, compared to the non-receptive cluster.

Note 21: For example, Landstrom et al. (2007) found that belief in the effectiveness of functional foods and diet-related problems among family members were better predictors of consumption of functional foods than were demographic characteristics.

Note 22: In other words, they are not simply male or female, or in a particular age group as opposed to another, but, for example, a female, aged 30, with a particular level of education, in a particular income bracket, and with a set of specific beliefs about functional foods as well as specific concerns about health-related issues.

Note 23: Their 2002 survey found that 62% of respondents were consuming between one and three "specific foods for functional health benefits", a 10% increase since 1998 (IFIC, 2002).

Note 24: They asked their sample of Swedish respondents which of a list of seven functional food products available in Sweden they had bought.

Note 25: 13.3% of respondents in the receptive segment were consuming at least three of the seven functional foods included in the questionnaire, compared to 5.8% of respondents in the non-receptive segment.

Note 26: For example, consumers may expect to find information about functionality on a yogurt, but would not be looking for such information on something like a chocolate bar.

Note 27: For example, those who scored highly on the "personal reward", "belief in benefits" and "support for functional food" aspects of the scale were more likely to have bought cholesterol-lowering products (Landstrom et al., 2007).

The "personal reward" aspect of the scale considered perceptions about how functional foods could promote well-being, performance, health and mood – e.g. agreement with the statement "The idea that I can take care of my health by eating foods with health claims gives me pleasure". The belief in benefits aspect of the scale included beliefs about the disease-preventing abilities of functional foods, availability of healthy foods and the willingness to consume functional foods on a health-care professional's recommendation – e.g. agreement with the statement "I can prevent disease by eating foods with health claims regularly". The "support for functional foods" aspect addressed how supportive the respondent was of the development of functional

foods – e.g. disagreement with the statement "The growing number of foods with health claims on the market is a bad trend for the future".

Note 28: Tuorila and Cardello (2008), in a study testing reactions to functional orange juice on a sample of volunteers from the US army, found that likelihood of consumption was strongly correlated with the respondents' liking for the juice, as well as being inversely correlated with the frequency with which it had to be consumed to obtain the health benefits.

Note 29: At the same time, the proportion of people claiming to accept functional foods that tasted as good as conventional foods remained relatively stable, at around 45-50%.

5.7 Notes on synthetic biology

Note 1: Synthetic biology is a highly novel technology with applications in a variety of fields; prominent developments include non-food biomass and medical/pharmaceutical applications. Artificial enzymes and bacteria are found in many everyday products, for example, biological washing powder. However, these are produced using accelerated 'directed evolution' from naturally occurring organisms, whereas synthetic biology involves engineering complex artificial biological systems from scratch according to desired specifications (Andrianantoandro et al, 2006). Although there may be potential implications for agriculture - for example, engineering corn to maximise ethanol production, evidence is unavailable about synthetic biology's direct applications to food.

Note 2: 62% of those with low concern for other risks agreed that benefits outweighed risks for synthetic biology, compared with 48% of those with high concern for other risks.

Note 3: 51% of hierarchs agreed that the benefits of synthetic biology outweighed the risks, compared to 58% of egalitarians. 47% of conservatives agreed compared with 64% of liberals.

Note 4: According to Professor George Annas of Boston University School of Medicine, bioethics and human rights overlap almost completely. He traces the origin of bioethics to the Nuremberg Principles as enunciated in the "Doctor's Trial."

> Citizen Con: "I have the right to live on a planet not infested with monsters created by ego-tripping synthetic biologists."
>
> Citizen Pro: "I have the right to allow scientists to take reasonable risks in order to study things that might save my child's (mother's, father's, grandparent's, own…) life – and alleviate enormous amounts of human suffering."

(http://openwetware.org/wiki/Synthetic_Society/Mohr_on_perception)

Note 5: 60% of men agreed that benefits outweighed risks, compared to 50% of women. 56% of white respondents agreed compared with 51% of ethnic minorities, although multivariate analysis showed that this was not a defining factor.

5.8 Notes on novel food processes

Note 1: For example, Cox et al. (2007) surveyed 453 Australian consumers (not a strictly representative sample) and segmented the respondents into three groups based on their beliefs about three novel food technologies – electron beams, triploidy and irradiation – with respect to prawns. The three segments had positive, negative and intermediate attitudes towards the technologies, and the group with positive attitudes only consisted of 15% of the sample. The group with negative attitudes made up 17% of the sample, while the rest were relatively neutral.

Note 2: Deliza et al. (2005) surveyed the Brazilian population (non-representative sample) and found that when people are simply told that a product 'has been processed using high pressure technology', this gives them a negative impression – they suggest that this could be because

people are not familiar with the term or the technology – but when an explanation of the benefits of high pressure processing is included, people are left with a positive impression of the technology.

Note 3: For example, Cardello (2003) found that nearly 70% of his sample (n= 88, non-representative) expressed some level of concern (either 'slight', 'moderate' or 'extreme' concern) about the addition of bacteriocins to food, while 65% were concerned about the use of pulsed X-rays, just over 40% were concerned about the use of modified atmospheres, and just under 30% were concerned about the use of hydrostatic pressure. The participants were also asked to rate their levels of concern on a 5-point scale (where 1=low and 5=high). Again, the addition of bacteriocins to food topped the list, with average concern levels of around 3 (female respondents averaging at just over 3.25 and male respondents at just over 2.75).

Note 4: For example, research (n= 225, non-representative) by Cardello et al. (2007) suggested that, across a range of novel food technologies, people appear to be more comfortable with technologies applied to plant products rather than animal products. Note that one of the technologies considered as part of this study was genetic modification, where it is widely reported that attitudes towards plant-based GM food are more positive than attitudes towards animal-based GM food, and it is by no means certain that the same will apply to every novel food process.

Note 5: In Germany, 74% of consumers were willing to buy high pressure processed food, while in France this figure was 71% in France. As in the UK, the majority attached a condition to this.

Note 6: Miles et al. (2004) for example, found that on average, people were more concerned about technology-related food risks than lifestyle-related food risks, because they felt more in control of the latter (n= 1,092, quota sample with characteristics similar to the UK population).

Note 7: Interestingly, concern ratings decreased not only for the technologies which the food samples had been processed by, but for some of the other technologies as well.

Note 8: Cardello (2003) found that for a range of 20 processing technologies, women consistently rated their levels of concern higher than men (n=88, non-representative). Cox et al. (2007) investigated people's attitudes towards three technologies with respect to farmed prawns in Australia, and segmented their sample into three groups based on their attitudes: negative, positive and neutral. The negative and neutral groups included a higher proportion of women, while the positive group included a higher proportion of men (n= 453, not strictly representative).

Note 9: Miles et al. (2004) found that, in a quota sample of 1,092 UK residents, women were more concerned than men about a range of food safety issues considered (including GM food, food additives and the use of antibiotics in food production).

Note 10: Butz et al. (2003) categorised their respondents into 'buyers' and 'non-buyers' of high pressure processed orange juice, and found that 28% of buyers were under 30, compared to 22% of non-buyers. In contrast, 27% of non-buyers were over 59, while 20% of buyers were over 59. The age group 30-59 were almost evenly divided between the two categories.

Note 11: Cox et al. (2007) investigated Australian consumers' attitudes towards three novel processes in farmed prawn production, and segmented their sample into three groups on the basis of their attitudes: positive, negative, and a middle group. Those in the positive attitude segment were significantly more likely to indicate an intention to purchase prawns treated by electron beams and by irradiation those in the middle segment. There was no difference between these two segments with respect to their intentions to purchase triploid prawns. Those in the middle segment were significantly more likely to indicate an intention to purchase prawns treated by electron beams and by irradiation, as well as triploid prawns, than those in the negative attitude segment. Within the positive, middle and negative segments, there was also some variation in which type of prawn they were more or less likely to buy, although in all cases this

seems to follow a similar 'gradient' through the three technologies. The positive and middle segments were most likely to buy normal prawns, then triploid prawns, then prawns treated with electron beams and finally irradiated prawns. The negative segment were more likely to buy normal or triploid prawns (with no distinction between these two technologies) and less likely to buy prawns treated with electron beams or irradiation (with no distinction between these two).

Note 12: The respondents also became more opposed to the processing method if it increased the price of the product.

Note 13: Respondents were initially asked to rate how much they liked chocolate pudding, and to rate their level of concern over a range of novel food processing technologies. They were then asked to rate how much they expected they would like chocolate puddings processed using some of these technologies. After this, they were given chocolate puddings to taste, which had been processed using these technologies, and asked to rate their liking for each. The results showed that concern over a technology influenced expected liking (in proportion to the level of concern), which in turn influenced actual liking. , suggesting that people's attitudes had an influence on their evaluations of the actual product.

Note 14: Both the French and German samples were found to have more positive attitudes towards HPP juice than the UK sample. The French were found to be willing to pay a premium for HPP juice, while the Germans – like the UK sample – were not. While the UK and German samples set as their conditions for consuming HPP juice that it should not be more expensive than standard and that is should provide an additional benefit, the most important condition set by the French was that quality should not be compromised by the processing method (compared to less than 10% in the UK and Germany who felt this was important).

Note 15: Wilcock et al. (2004) quote figures from the literature which show that in 1992, 10% of the US population felt that the safety of processing of food was a concern, and by 1996, this figure had declined to 8%.

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6.1 Overall findings

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Appendix A - Methodology

Inclusion and exclusion criteria (as specified in the research brief)

Exclusion Criteria

- Exclude anything published before 1999. (NB in report have a historical analysis that recognises difference in perceptions according to the date of the research).
- Exclude newspaper articles but explore any report references cited in the article.
- Exclude any research that is not relevant to food.
- Exclude any research that does not address consumer views (i.e. if it is about technology only, discard it).

Inclusion Criteria

- Include English language reports only.
- Include worldwide research.
- Include new technologies from 1999 onwards.
- Include any method.
- Note in report the quality of research used as evidence (including whether it has been peer reviewed/ published in a journal)

Successful search terms

Successful[138] search terms in included:

- **Animal cloning**: animal cloning public opinion.
- **GM and biotechnology**[139]: GM; public attitude genetic modification; GM public attitude; public attitude genetic modification food UK 2008; public attitude genetic modification food UK 2005-2008; public opinion GM 1999-2008; public attitude biotechnology food 1999-2008; animal cloning public opinion; novel food processes consumer attitude; novel food processes consumer opinion; food innovations public opinion; food irradiation public opinion; functional food public opinion; functional food consumer perception; food nanotechnology consumer attitude.
- **Novel food processes:** novel food technologies; food irradiation; food irradiation consumer perception; food irradiation public opinion; food irradiation public attitude; new food processing technologies consumer perception; consumer perception high pressure food processing; public attitude thermal processing; novel food processes public attitude; food irradiation public attitude; food irradiation public opinion; food nanotechnology consumer attitude.
- **Food irradiation**: food irradiation; food irradiation consumer opinion; food irradiation consumer attitude; food irradiation public perception; food irradiation public attitude; food irradiation public acceptance; public attitude OR opinion OR view OR perception "food irradiation".
- **Nanotechnology**: food nanotechnology public opinion; food nanotechnology consumer attitude; food nanotechnology consumer opinion.
- **Functional foods**: functional food trends; functional foods public opinion; functional foods public perception; consumer view functional foods.
- **Synthetic biology**: synthetic biology public opinion; synthetic biology food public opinion.

[138] i.e. search terms which wielded results
[139] n.b. articles relevant to GM were found when looking for articles in other areas

Spreadsheet used for recording source material

5	DETAILS						CONTENT			SOURCE QUALITY				METH
6	Title	Year	Location (Link/in library?)	Search terms/ search engine	Country	Comments	Keywords	Summary	Abstract	Source	Rate quality of source (use drop down list)	Justification for source rating YOU MUST FILL THIS IN	Source score	Meth
7	15													
8	The North Am	2006	library	food nanotechnology public opinion	Canada & US		Nanotechno	survey in US	A January 2	http://www.	High	Journal	3	Telep
9	Public Percept	2005	library	food nanotechnology consumer attitude	USA	Not specifi	Nanotechno	results of a	na	http://www.	Medium	Woodrow Wilson	2	12 foc
10	Affect, Values,	2007	library	food nanotechnology public opinion		Includes a	Nanotechno	how do peo	Despite knc	http://pape	Medium	Unpublished work	2	survey
11	Intentions of N	2007	In library	FSA list	New Zealand.		Nanotechno	This paper aims to provi		British Libr	High	British Food Jou	3	Data
12	Nanodialogues	2007	In library	FSA list	UK		Nanotechno	explored public views of		Demos	Medium	Not peer reviewe	2	13 mer
13	Public Attitude	2005	library	food nanotechnology public opinion	US?		Nanotechno	emotions m	Previous st	http://sox.s	High	Journal	3	Analys
14	New Zealander	2006	library	food nanotechnology consumer opinion	NZ		various: biot	includes nar	na	http://dspa	Medium	Unclear if this is p	2	postal
15	Nanologue	2006	Saved one	FSA list	Europe		Nanotechno	Nanologue's	overarchin	http://www.	High	EU funded	3	variou
16	Nanoscience a	2004	In library	FSA list	UK		Nanotechno	Independent	study on nai	Royal Soci	High	Royal Society	3	Quick
17	Perceived risk:	2008	In library	FSA list	Switzerland		Nanotechno	German speaking part of		Dialogue a	High	Journal	3	Mail S
18	Public accepta	2007	In library	FSA list	Switzerland		Nanotechnology		The percept	AppetiteVc	High	Journal	3	Survey
19	Nanojury witne	2005	In library	From refs of row 7	UK		Nanotechnology			Civil soc pı	Medium	Some bias?	2	Citizer
20	Democratic te	2007	In library	FSA list	UK	Not exactly	Nanotechno	Report explored attempt		involve	High	JRF	3	Invest
21	http://www.smalltalk.org.uk		http://www.smalltalk.org.uk/page11g.html		UK	Results of	Nanotechnology			smalltalk.o	High	Small Talkwas a c	3	Variou
22	Biased assimil	2008	In library	Search of Woodrow Wilson Centre Project	USA	Not specifi	Nanotechnology			http://www.	Medium	Woodrow Wilson	2	Survey
23														
30														
31	Imagining nanc	2005	In library	from refs in row 23	USA and E	Not just ab	Nanotechnology		This paper c	Public Und	High	Journal	3	Survey
32	Nanotechnolo	2006	library	food nanotechnology public opinion	US	Not specifi	Nanotechno	What do pec	Public perc	http://pus.s	High	Journal	3	3 by 4
33	What drives pu	2006	library	food nanotechnology public opinion	UK?	Not specifi	Nanotechno	large scale s	How do the	http://www.	High	Journal	3	4,542
34	Climate Chang	2003	library	food nanotechnology public opinion	UK		biotechnolo	Tracks publi	The 1991-20	http://www.	High	Journal of Agrob	3	Eorob
35	Risks and nanc	2007	In library	FSA list	Switzerlanc	Nano: 20 a	Nanotechnology		The public p	Nat Nanot	High	Journal	3	we ask
36	Scientists worr	2007	library	food nanotechnology public opinion	USA	Not specifi	Nanotechno	differences	A comparis	http://www.	High	Journal	3	genera
37	FDA and Nanc	2008	In library	Search of Woodrow Wilson Centre Project on Emergin		Not specifi	Nanotechnology			http://www.	Medium	Woodrow Wilson	2	summ
38	In the Public Eı	2005	library	food nanotechnology public attitude	Canada &	Not specifi	Nanotechno	What do Car	Nanotechn	http://www.	High	Journal	3	Telep
39	Qualitative sys	2008	In library	FSA list	Switzerlanc	Only a bit a	Nanotechno	Sustainable governance		British Libr	High	Journal	3	This p
40	Deliberating Ri	2007	library	food nanotechnology consumer attitude	Switzerlanc	More gene	Nanotechno	qual work or	Scientific kr	http://www.	High	Journal	3	Series
41	Falling Througl	2006	library	food nanotechnology public opinion	USA	Got stuff o	Nanotechno	claims to lo	Nanotechn	http://ieeex	Medium	Woodrow Wilson	2	Discu
42	Framing Effect	2005	library	food nanotechnology public opinion	US	Not specifi	Nanotechno	How do peo	In this study	http://sox.s	High	Journal	3	Discu
43	Applications ar	2008	In library	just found in library, after these had been shortlisted - not about public opinion but all about food										
45														
46	Toxic effects c	2006	library	food nanotechnology public opinion	UK?		Nanotechno	potential for	Nanomater	http://www.	High	Journal	3	Revie
47	Nanotechnolo	2007	library	food nanotechnology public opinion		Nothing ab	Nanotechnology		na	http://www.	High		3	Discu
48	Nanotechnolo	2008	In library	FSA list			Nanotechno	This paper h	Public awar	British Libr	High	Journal	3	Revie
49	From our read	2004	library	food nanotechnology public opinion		Not specifi	Nanotechno	response to an article		http://www.	High	Journal	3	review
50	Nanotechnolo	2004	In library	FSA list	UK	Not about	Nanotechno	The quantitative researcl		Prepared b	Medium	Not peer reviewe	2	Quant
51	Nature on nanc	2005	In library											

Nano | Nano SHORTLIST | Functional foods | Functional foods SHORTLIST | Synthetic biology | Synbio SHORTLIST | Exclusions

Figure 1 Example of the prioritisation

Spreadsheet used for recording information from the detailed review

	A	B	C	D	E	F	G	H	I	J
1	18			DETAILS				RQ1 What are the public's views?		
2	Full citation	Title	Year	Summary	Abstract	Country	Methodology	Summary	Detail	Thougts (relevance, links, analysis etc)
23										
24	Frenzen, P.D., D	Consumer acc	2001	influence of c	Food manuf	US	tele survey	Their lit review refers to risk perception studies which indicate the public considers food irr-		
25								Their survey (non-representative sample of US residents) found that 48% had heard of irrac		
26										
27	He, S., Fletcher,	Attitudes, acc	2005			US	tele survey	They carried out a telephone survey in the US (appears reasonably representative, though t		
28								The survey also found that a	They suggest these inconsistencies could be due to people g	
29								The respondents were also	They suggest these inconsistencies could be due to people g	
30										
31	Frenzen, P., Maj	Consumer acc	2000			US		Their lit review notes that surveys typically find that around 50% of respondents (at least in		
32								They also note in the lit review that there was huge opposition to the USDA's proposal in 1		
33								The results of the FoodNet	They report on the results of the FoodNet survey (the other re	
34	Grande, J., Bjorn	Assessment of Consumer Risk Attitudes and Behaviour Related to Countermea						A survey carried out in Scotland (random sample of 200 respondents, representative in ter		
35								The Scotland survey also found that on a scale from 1 to 5 (where 1 is not at all worried and		
36	Hunter, C. (2000	Changing attit	2000			US		Figure 1 in the paper lists the reasons why people would buy irradiated food, and percentage		
37	Fox, J., Bruhn, C	Consumer acceptance of irradiated meats						The lit review refers to a US study (no details provided) which found that when people were		
38								The lit review also refers to a Gallup poll in 1993 where respondents ranked food irradiation		
39										
40										
41	Young, A.L. (200	Food irradiatic	2003					The article claims that with things like pesticides, processing etc. people feel that there is n		
42	Hashim, I.B., Mc	Consumer pur	2001				They used a simul	ated supermarket setting, which they say gives purchase behaviour data (unlike surveys whic		
43							The simulated sup	ermarket had chiller cabinets with 4 types of beef: minced vs non-minced, and lean vs expen		
44							N=207, mainly ups	cale white sample, with better educated and higher income people slightly overrepresented c		
45										
49	Henson, S., Ann	Understanding	2007	Canada	risk percepti	can't copy a	repertory grid inter	view and structured questionnaire		
50	Wilcock, A., Pun	Consumer atti	2004			Consumers' attitudes have bee		Their lit review refers to evid "Food irradiation appears to be gaining consumer acceptanc		
51	Brewer, M.S. anc	Consumer atti	2002	US		The objectives of this study were		to evaluate consumer attitudes regarding the safety of the food supply, relate food safety		
52	Ronteltap, A., va	Consumer acc	2007			Determinants of consumer ado		Their lit review refers to "significant consumer resistance" to food irradiation.		
53	Cardello, A.V., S	Consumer per	2007	US				They found (not a representative sample, data from US) that people respond more positive		
54	Johnson, A. M.,	Consumer atti	2004	people are m	A survey was	US	?	The lit review notes that because few consumers have firsthand experience of irradiated fo		
55								Their survey suggests that people are more concerr	So not top of the list then.	
56								Of their respondents, 44% felt that irradiation of fruit is necessary, 38% the same for vegeta		

Figure 2 Example page of spreadsheet used to record full detail of sources

Successfully contacted organisations

In total, 16 people kindly responded to our call for information on any recent or forthcoming research, or confirmed that no relevant research was being done within their organisations. They came from the following:

- University departments and academic research institutes (7);
- Non-governmental bodies concerned with science and/or public perceptions of science (3);
- Market/ opinion research agencies (3);
- Government departments and institutions (2);
- Think tanks (1).