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The Prospects for Acceptance of Animal Cloning in the European Food Chain: Early Insights from an Irish Sentinel Group

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European stakeholders will soon face a decision regarding the acceptability of livestock cloning. Commercial exploitation of cloning for food purposes within the European Union will require an insight into public sentiment, and a communication strategy that addresses risk perception. The present study canvassed the opinions of expert stakeholders within the Irish arena.

Respondents surveyed did not identify animal cloning as an impending food priority issue, and there was little evidence of in-depth awareness regarding the advanced developmental stage of this technology. Specific probing around this topic revealed varying receptivity to the idea of cloning for food purposes. Interestingly, with certain exceptions, a primarily utilitarian ethical perspective (based on perceived risk-benefit), rather than outright rejection on principle, appeared to inform interviewee opinion on aspects such as animal welfare and consumer choice. However, the near-term prospects for adoption of cloning for food were largely viewed with skepticism.

Key words: animal cloning for food, expert Irish stakeholder awareness, ethical perspectives, market prospects.

Introduction

The current Irish National Development Plan identifies biotechnology as a driver of economic growth (Anonymous, 2007; Department of Agriculture, Fisheries and Food [DAFF], 2010). Freedom to operate in the market and the ability to raise investment capital based on societal acceptance are central to the successful translation of technology into wealth creation. However, the negative European experience with genetically modified (GM) plants has created a new business paradigm whereby exploitation of GM technologies is retarded, and indigenous GM technology development is stunted. This misalignment between "technology push" and "market pull" can have severe consequences for those wishing to exploit such technologies. Technology developers can be faced with the situation of having succeeded in gaining intellectual property protection and the marketing authorization of regulatory authorities but having no freedom to operate in the marketplace. The first generation of GM foods, epitomized by Monsanto's Roundup Ready® crops, were widely perceived by the European consumer as offering benefit only to the producer (Williams, 2000). Public concern based on perceived risk and food safety, rather than an intrinsic rejection per se, has been witnessed with such products (reviewed in Bryant, Baggot la Velle, & Searle, 2005), and this observation is a critical one for companies wishing to progress other food biotechnology applications.

With the notable exception of tardy approval of GM feed by the European Union, the barriers to trade and development of GM plants has arguably had limited relevance to Irish agriculture. However, the situation regarding new biotechnology innovations in animal breeding is likely to be quite different. The agri-food sector accounts for 8.1% of total employment and 9% of total exports in Ireland (Irish Cattle Breeding Federation Society [ICBF], 2007). Cattle-farming is the primary form of agriculture in terms of livestock numbers, and accounts for 54% of total agricultural output. Ireland exports nine out of every ten beef animals, which makes it the largest beef exporter in the European Union and one of the largest in the world (Teagasc, 2008). The continued success of this sector is underpinned by the rapid adoption and integration of the latest technological innovation, so productivity can be maximized in a sustainable fashion. Modern breeding techniques seek to overcome challenges that reduce profitability, such as limitations posed by natural service, infertility, disease transmission, feed conversion inefficiency, and inconsistencies in food safety/quality. One of the best examples of this has been the translation of DNA analysis and functional genomics developed for human medicine into the area of animal health and breeding (Lambert, 2008). The integration of genetic marker data into existing Economic Breeding Indices (EBI; based on herd record data, such as milk yields) is well-advanced in Ireland

(Berry, Kearney, & Harris, 2009; Evans, 2008). Such technology permits the more reliable translation of genotype to phenotype and increases the chances of retaining desirable traits such as disease resistance and meat quality in progeny animals (Cunningham & Meghan, 2001), therefore producing animals that command a higher price. However, absolute certainty of the inheritance of desirable traits from generation to generation can only be assured by a method that circumvents genetic recombination (via meiosis) and mingling of the male and female chromosome complement during sex. Cloning is the only means of achieving this.

The cloning of superior pedigree livestock, which offers high productivity and consistent quality, is now a technical and commercial reality in the United States. Will breeders be at a competitive disadvantage if such technologies are not deployed in Ireland? Should research funding agencies support the indigenous development of cloning technologies, so Ireland is not relegated to becoming a net importer of such innovation? Clearly, insight into such questions hinges on the response of society (and the prospective consumer). The precedent regarding the existing use of biotechnology in agriculture might imply a negative response to such questions; however, the intersection of economics, technological strength (with perceived national importance), and market opportunity in conventional animal production, with its attendant societal reservations regarding the treatment of animals, does not appreciably limit this sector (Institute of Grocery Distribution [IGD], 2007).

With a view to providing an early insight into the prospects for acceptance of animal cloning technology in Ireland within a food context, the present study describes the results of a series of in-depth qualitative interviews conducted with "expert" stakeholders. The definition of expert that was used to select interviewees was based on factors such as job responsibilities and actual or potential involvement in cloning-related areas. In being empowered to keep a watching brief on food technology, market, or regulatory developments, such individuals might be expected to fulfill a sentinel function (or in common parlance, possess a finger-on-the-pulse position regarding the future of animal cloning into the agri-food sector).

Background

Consumer trust and risk perception are paramount in the consideration of the launch of any new food product (Huotilainen & Tuorila, 2005). Before the emergence of the various food crises in the early nineties, public trust in national and EU risk evaluation mechanisms remained largely untested; such systems relied on a technocratic framework that stressed the scientific method and featured relatively little involvement of the public in actual decision making (Radaelli, 1999). In the intervening period, a new model of governance has emerged which seeks to complement scientific evaluation by embracing the idea of egalitarian information networks, thereby supplanting the hierarchies as an integral component of state-society relationships (Bache, 2003; McCrea, 2005; Shepherd, 2008). Central to such greater openness of the regulatory system is the adoption by government of a coordination and facilitation stance, rather than a more traditional one of command. In the wake of public disquiet on issues such as GM foods and bovine spongiform encephalopathy, Europe has sought to increase public confidence through the transparency of risk analysis and by increasing stakeholder participation. Central to effective risk governance is a recognition of the current and future needs of key stakeholders in the debate. The early identification of emerging technologies that may pose acceptance issues for the public is vital.

Undoubtedly mindful of the variable public reaction to GM crops, both US and EU regulatory agencies have been keen to assess the development of animal cloning for food purposes within the context of specific consumer concerns. Putative benefits for animal health and human nutrition such as disease resistance, productivity, and product consistency (Wheeler, 2003) vie with basic questions regarding food safety, market need, cost effectiveness, potential trade implications, and a host of divergent ethical dilemmas (Rosenbergen, 2007; Suk et al., 2007). Following an initial draft report published in December 2006, the United States Food and Drug Administration (US FDA) published a comprehensive risk assessment in January 2008, which concluded that edible products from clones and their offspring (cattle, swine, and goats) were as safe to eat as their conventional counterparts (US FDA, 2008). However, perceived ethical issues have been a potential stumbling block in Europe. The European Food Safety Authority (EFSA) initially published a favorable draft opinion (dealing only with cattle and pigs), which indicated that food safety concerns were unlikely (EFSA, 2008). However, the European Group on Ethics in Science and New Technologies (EGE) to the European Commission (EC) subsequently cast doubts about the ethical acceptability of animal cloning (EGE, 2008) on the basis of the current high mortality rate among clones, and ancillary welfare concerns. Since a consideration of animal wel-

fare is an integral aspect of EU agricultural policy, the European Parliament subsequently passed a resolution that such technology should be summarily banned from use in the food sector (Anonymous, 2008). While the EC has not yet accepted such a proposal, the intervening years have seen EFSA conduct widespread consultation with stakeholders and an ongoing assessment of newly published scientific data regarding the safety of food from clones. Although no evidence has emerged to alter the original conclusions of their 2008 report (EC, 2010), the discovery in Britain in August 2010 that the produce of cloned offspring had inadvertently entered the British food chain (Meikle & Phillips, 2010) highlighted deficiencies in the regulatory system. It also revealed confusion in the interpretation of existing European legislation. A consensus agreed that meat derived from clones would be required to be formally assessed for safety and approved under Regulation EC 258/97,[1] but the situation regarding clone offspring was revealed to be less certain. For example, the British Food Standards Agency contended that offspring should also be subject to EC258/97 (FSA, 2010), while the European Commission disputed this (EurActiv, 2010a). Developments culminated in late 2010, when the European commission proposed a temporary, 5-year suspension of animal cloning for food production in the European Union (which would not be applicable to clone offspring; EC, 2010). At the time of writing, such a proposal has yet to be approved by the European Council and the Parliament, and Britain has criticized the move as being unjustified. Looking to the longer term, it is probably more likely that cloning may be regulated under new bespoke legislation (EurActiv, 2010b) rather than be incorporated into the long-overdue revision of the novel foods regulation. Such continuing regulatory uncertainty is reminiscent of the EU market landscape for GM foods in the early 1990s, which extends to the current day, and does not bode well for the integration of clone-derived products into the food chain. Traceability issues also loom, and the United States has already established a voluntary tracking system (Hodges, 2010) in anticipation of requirements in Europe.

These developments received widespread news coverage in the latter half of 2010 (for examples, see Anonymous, 2010; Poulter, 2010) and undoubtedly raised the consciousness of the general public both to the existence of cloning in agriculture and the imminent arrival of cloned produce in the marketplace. Only a few studies of European public attitudes to the concept of animal cloning for food purposes were conducted before this time period. The largest was the Flash Eurobarometer study published in 2008 (EC, 2008).[2] The latter indicated ethical reservations about animal cloning, and the majority rejected its use in the food chain. A very high number of interviewees had heard of cloning and had some degree of understanding of cloning basics, but such results may be partly explained by assimilation of the concept into popular media such as literature and film, and its actual embodiment in Dolly the sheep, the first mammal to be cloned from an adult cell (FSA, 2009). It should be pointed out that the slippery slope hypothesis, basically that cloning will be perfected in animals and then applied to humans, is a recurrent and common theme in popular culture (Fiester, 2005).

It is noteworthy that Eurobarometer has been specifically sampling attitudes to biotechnology regularly since 1991, but did not contextualize animal cloning within an overt food context until the 2008 study. Previous surveys sampled opinions on issues such as the use of clones in human medicine and the use of GM animals in laboratory research. Such an omission could reflect either a lack of awareness regarding the development status of this technology for food applications or a purposeful relegation of its importance to the European citizen based on an assessment at the time. By 2010, the issue of cloning animals for food became a staple of the mainstream "biotechnology Eurobarometer" (Gaskell et al., 2010), which again signaled a low level of support for its use in food production.

Purpose of the Study

The primary aim of the current work was to investigate the topic of farm animal cloning with a panel comprising key Irish stakeholders. Exploration of the current awareness of this group regarding the development status of the technology was sought, along with some insights into their attitudes to cloning within the context

1. *Novel Foods Regulation applies to food and ingredients not consumed in appreciable amounts in the European Union before May 1997.*

2. *Eurobarometer is a pan-European survey instrument designed to glean the opinions of citizens from existing (and often future) European Union member nations on topics of existing or emerging importance. Each national survey consists of approximately 1,000 face-to-face interviews (usually) that feature identical questions. The total sample size has increased as the European Union has grown in member states, and as of 2011, the number of interviewees exceeds 25,000 persons.*

Table 1. Interviewee classification.

Organization type	Primary role / responsibility	Qualification (highest)
Government agency	Company support, meat sector	MSc
	Advisory, company business support	MSc
	Advisory, regulatory, ethics	PhD
	Industry analyst, animal-derived foods	MA
	Regulatory, food safety	PhD
	Research, animal productivity	PhD
University	Reproduction, animal	DSc
	Genetics, animal	PhD
	Immunology, human-animal	PhD
	Scientific communication	PhD
Private company	Beef production	HDip
	Animal breeding	MSc
	Retail sales	MSc
	Venture capital, emerging technologies	PhD
Non-governmental organization (NGO)	Agriculture, public representation-lobbying	MSc
	Farming, organic, public representation-lobbying	MA
	Farming, organic, public representation-lobbying	MSc
	Animal welfare, public representation-lobbying	BSc
	Animal welfare, public representation-lobbying	BA
Religious body	Christian	MSc

of biotechnology, food, and agriculture. A secondary aim was to examine spontaneous thought processes on issues such as ethical reasoning pertaining to animal exploitation in biotechnology and agriculture.

Data Collection and Methodology

The key criterion for inclusion of interviewees in the study was the perceived relevance of the person's day-to-day role to the emerging issue of animal cloning in an agri-food context. In general, interviewees occupied senior positions in administration, business development, or academia; possessed a responsibility to actively seek out information with a view to increasing personal and organizational intelligence; and were judged to possess a high potential to be influential in the emerging national debate on cloning. Reflecting the trend for increased participation of non-government actors in national policy formation (Barling, 2007), interviewee organizations spanned universities, industry, animal welfare and consumer-citizen representative groups, and government agencies (Table 1).

Interviewees (n=19) were primarily identified through a proprietary national contacts database, and this was supplemented by identifying key individuals on the basis of authorship of relevant peer-reviewed publications and government reports. Two respondents—one from a university in the field of human-animal immunology and another in the field of animal breeding from a private company—were recommended by other interviewees in the course of the study.

The format used for data collection was a semi-structured, in-depth interview, which featured questions covering five major themes: food industry, technological innovation, societal perspectives, exploitation of non-human animals, and moral aspects. The subject of animal cloning was initially contextualized during interviews against a general background of an evolving food biotechnology sector, and the relevance of this to the Irish agri-food system. The majority of interviews took place at the interviewee's work place between October 2009 and January 2010 and lasted between 1 and 2 hours. Interviews were digitally recorded (supplemented by written notes) and were later transcribed. Analysis of the coded interviews was carried out using NVivo7 software (*QSR International*), with specific examination for content pertaining to the research objectives.

Results and Discussion

Interviewees were initially asked to identify priority issues, opportunities and challenges, that is, for the European food sector. Only a single person cited the emergence of animal cloning for food purposes as an

unprompted, top-of-mind issue, liable to emerge over the short-medium term. A food safety representative working in regulation for a government agency said during the interview:

> "I suppose novel food is the busiest [area], but nanotech and the animal cloning are busier now because the Novel Food [Act] is being revised, and there's new legislation coming and it's going to include animal cloning. When I say include, it's going to include it… include it to ban it, which doesn't make sense. … Nanotechnology was as mentioned as well. They're on the horizon at present in other countries, not in Europe yet, but it's coming down the tracks. So it's important to keep ahead of those."

Further discussion revealed that with only a few exceptions, formal discourse on the topic of animal cloning at the organizational level had not occurred to any significant degree. Only a single participant organization had incorporated such debate into a policy document (at the time of interview). There was little evidence that this reflected a conscious relegation of the issue to a lower level of importance on the basis of detailed consideration. Rather, it was the level of awareness regarding the progress of such innovation for food purposes that appeared to be low; interviewees were generally reactive to questions concerning cloning rather than proactive in demonstrating a knowledge of the key aspects. It is important to highlight that the interviews pre-dated the much-publicized United Kingdom clone incident described by Meikle and Phillips (2010) by six months.

While receptivity to the idea of cloning for food purposes varied among interviewees, the near-term prospects for this technology were largely viewed with skepticism. A person interviewed in retail sales for a private company said,

> "I would say it's just about got no chance, probably because the producer just won't bother to go there—too expensive. In the short term, and 10 years is the short term in this technology, [it is] too expensive to be at all viable."

Interviewees demonstrated good awareness of the uses of modern technology in food production, and interestingly over half advocated a role for genetic modification as a component of plant breeding. A similar number expressed doubt on the putative health benefits of functional foods. However, with the exception of interviewees directly engaged in the animal or meat sectors, an awareness of more near-term technologies in animal husbandry was not apparent. Additionally, knowledge relating to high profile failures of animal biotechnology such as the 'Beltsville pigs'[3] (Tansey & D'Silva, 1999), or newer GM innovation such as 'Enviro-pig'[4] (Minard, 2010) was not apparent. This reflects the wider European situation where public recognition of terms such as "genetic modification" and "cloning" is higher than terminology such as "genomic selection" (Gibbs, Holloway, Gilna, & Morris, 2009).

Following on from this, objective knowledge about the role of currently used assisted reproductive technology (ART) in animal breeding varied widely. Artificial insemination (AI) was the primary reference point for most interviewees who were not directly involved in this sector. Respondents who possessed a technology background and demonstrated a knowledge of ART differed in opinion on the commercial viability of techniques such as embryo transfer and splitting. The value of the animal was of paramount importance in the consideration of this option. A university employee working in reproduction said,

> "So AI could be used more in the dairy [industry]. AI is not used widely in the beef side. Embryo transfer is only used for high-value animals that tend to be pedigree animals. I don't think you can say much more about that."

Greater consensus was apparent in those possessing a technology background on the issue of farm animal cloning. More than half agreed that cloning could be viewed as "an extension of the natural breeding process." A single reservation was registered relating to a perceived fundamental flaw of the technique: The incorporation of mature DNA into an egg was cited as a

3. *The US Department of Agriculture's Beltsville facility carried out the genetic modification of pigs using a bovine or human growth hormone gene to increase yield (Pursel et al., 1989). The pigs demonstrated increased weight gain and feed efficiency, and exhibited changes in carcass composition that included a marked reduction in subcutaneous fat. However, the pigs also had obvious physical deformities, including premature arthritis, dermatitis, and problems affecting their major organs.*
4. *Enviropig is a pig that has been genetically modified to excrete less phosphorus, with putative benefits for feed conversion and the environment.*

major pre-disposing factor for possible increased mutation rate and premature aging. There was also evidence of a close association of cloning with transgenic technologies in the minds of some respondents, perhaps reflecting an awareness of the origins of animal cloning technology within the human health (pharmaceutical) sphere. An animal productivity representative working in research for a government agency said during the interview:

> "No, it's a very big step; it's a very different approach altogether. The other technologies are really just assisting or trying to control or trying to enhance the normal process — maybe correct a hormonal deficit or maybe increase the number of eggs present — so to give you a better chance of one being fertilized or implanting multiple embryos, again in the hope that one at least would grow in the womb or whatever the term used. So they're all really just trying to *tweak* [original emphasis] the existing process. I suppose semen-sexing would be a bit outside tweaking the existing process, but cloning is definitely coming at it from a totally different angle."

The opinions of all interviewees were sought on the perceived issues that would influence the acceptance or rejection of animal cloning for food purposes by Irish stakeholders. Aspects such as predicted economic benefits, consumer and public perception, ethical implications, animal welfare, and social justice were identified as being important, but differences in emphasis were apparent.

Among those interviewees who could envisage a role for cloning in the food sector, a number of key factors were identified as being of critical importance in deciding its commercial future. Among these, the market performance of the technology in the United States, the required scale of operation, the feasibility of integration into existing farm practices (conventional and organic), and resolution of any outstanding questions relating to food safety were specifically mentioned. A company business-support representative working in the advisory role for a government agency said during the interview:

> "Investigate it. Get clear information on it. Establish the facts. See what the viability aspects of it are like, and if it's safe and passes the demands of food safety and all of that, there's something that has value in it. We haven't got information at this point to conclude that it's like that."

Virtually all respondents predicted a negative response among the public to the use of cloned animals for food purposes. Some felt that consumer education could be a positive modulating factor in gaining public confidence, but the validity for such assumptions are the subject of much debate (for example, see Knight, 2005). Representatives from the meat processing and retail sectors also hypothesized a possible role for cloning in delivering consumer-driven consistency in meat quality. The potential of harnessing the technology to reduce antibiotic use was also cited. An immunologist in human/animal research for a university said during the interview:

> "Everybody will benefit I think, and a big issue even just for general human health, [is] if you can raise animals without ever having to give them antibiotics. Isn't that immediately obvious as to how that's going to be a benefit?"

Several interviewees also elaborated on aspects that may represent catalysts for rejection by the public. Associations with human cloning and popular science fiction imagery including Shelley's Frankenstein (Shelley, 1818) were highlighted as possible determinants in influencing public attitudes to animal cloning, along with concerns revolving around food safety and animal welfare. Such findings have been previously reported for Europe as a whole (EC, 2008).

The personal viewpoints of interviewees were also sought in relation to the role of cloning in food production. Possible unforeseen adverse consequences of this approach were mentioned by eight respondents who expressed concern as to the adequacy of testing with respect to food safety and impact on the environment. Interviewees articulated instances in which putative advantages of the technology might also simultaneously represent a drawback. This was apparent on the issue of product consistency gains delivered through cloning, which essentially revolves around product uniformity regarding quality and would be achieved at the cost of a reduction in biodiversity. Trade-off issues were also recognized in relation to the requirements of animal welfare versus the need to deliver lower cost food at a time of global recession.

Reflecting this balance sheet approach, and with three notable exceptions, interviewees displayed predominantly utilitarian reasoning to analyse and express

their opinion on the morality of animal cloning. Although the issue of social justice, or the possible marginalization of small farmers, featured to a degree, half of the respondents cited animal welfare as the primary ethical concern, in line with recent findings (EC, 2008, 2010), and such arguments are already well-embedded in the European policy debate (Compassion in World Farming [CIWF], 2008; Gjerris, Lassen, Meyer, & Tveit, 2006; Lonergan et al., 2007; Madill, 2010; Vanhonacker, Verbeke, Poucke, Buijs, & Tuyttens, 2009; Wrenzycki et al., 2004). The consensus primary argument revolves around the current high mortality rate of clones. Established ART, such as artificial insemination in cattle, can have a success rate of 94%, which is almost ten-times as successful as cloning (Diskin & O'Farrell, 1998).

Implicit in such reasoning is that future improvement in the success rate of animal cloning, along with the evolution of a business model that would provide for equitable access to its potential, will most likely represent key development milestones for proponents of the technology. This is significant, as previous work in Ireland found that concern about animal welfare did not appear to outweigh food safety or quality issues in the minds of the consumer (Meehan, Cowan, & McIntyre, 2002). Coincidentally, interviewees in the present study cited cost and quality as the primary influence in food purchase decisions, rather than sustainability or ethical concerns.

The commercial origin of animal cloning technology within the pharmaceutical sector (Wall, Kerr, & Bondioli, 1997) and the successful approval of new medicines produced in the milk of transgenic animals[5] (Houdebine, 2009) are significant determinants in assuring the progress of cloning technology. Spurred by the need to exactly replicate valuable GM animals as a means to produce human biopharmaceuticals, sometimes referred to as "pharming" or "bio pharming," technology enhancements developed within this well-funded sphere will translate directly into agriculture. Medical uses of animal biotechnology, rather than agri-food applications, have well-documented, higher levels of perceived utility among the public, and the recognition of the societal value of pharming, with cloning technology at its core, might represent a gateway to its acceptance by the public for food use.

It is noteworthy that one industry representative believed that ethics was not a significant consideration in animal cloning. Indeed, it was articulated that should the technology prove profitable, national competitiveness would dictate technology adoption as a prudent strategy. These views were echoed by representatives from the breeding, farming and public funding sectors. An industry analyst working in the animal-derived food sector for a government agency said during the interview:

> "I think you look at… what's happening with the crops side over a couple of generations in terms of the disease resistance strains. Farmers have adopted those very well as standard, whereas on the livestock side, we haven't had that same level of development, in some ways, maybe. But certainly I would say from a farmer point of view, if there's obviously a benefit there, they will adopt it quite quickly."

A number of stakeholders did acknowledge a defined role for organized religion as active participants in the debate. While not having a fundamental objection to animal cloning per se, a representative from the Christian faith questioned whether the goals of this technology might only fulfil a short-term aim and raised concerns about future impacts on the environment. Other principle-based ethical arguments against cloning centred on theological concerns such as interference with the work of the creator, disrespect for nature, commodification of life, and the loss of species identity based on the Aristotelian concept of the telos, which is a respect for the unique end-purpose of a creature and is embodied within the context of its natural biological identity. Such concerns are well recognized in the literature (Pascalev, 2006). In an interview, one animal welfare specialist for a non-governmental organization said of cloning, "That's tinkering [with nature], that's really tinkering."

Summary and Conclusions

A current worldwide imbalance exists between the significant investment in biotechnology and research into its societal ramifications. As the lesson with GM plants illustrates, anticipating the market response to such technologies may be challenging. The difficulty is exacerbated by the paucity of effective mechanisms to com-

5. *Human anti-thrombin α (ATryn), which is an anticoagulant protein produced in the milk of transgenic goats, was approved by the European Medicines Evaluation Agency in 2006, and the FDA in 2009.*

municate the value of new technology to citizens and consumers. Anachronistically, increases in societal investment in technological development often correlates with heightened complexity of the end-product and its attendant alien syntax, and the result is a pronounced information asymmetry between societal groups. It is well acknowledged that average citizens lack the lexicon of modern biosciences, and sampling public opinion with a view to reconciling "technology push" with "market pull" issues in such instances is difficult (O'Connor, Williams, Cowan, O'Connell, & Boland, 2004).

Consumer and citizen acceptance is crucial to the development of successful food products (MacFie, 2007). Furthermore, public perception can have a strong impact, both direct and indirect, on the progress of new technologies (Siegrist, 2010). A direct effect might be outright rejection, whereas indirect effects could include the imposition of stricter regulations by government, perhaps leading to higher production costs. It might not always be mandatory to disclose information about how a product is produced or processed. However, the level of information available to the public and representative groups through traditional media outlets as well as contemporary interactive and online social media suggests it would be useful to gauge likely public acceptance of the technologies at an early stage rather than risk a backlash later (Cox & Evans, 2008). Consequently, public attitudes toward new food technologies should be taken into account by scientists, technologists and industry at an early stage of the development process (Siegrist, 2008, 2010) if the economic, social and other benefits of such investment are to be reaped. Such upstream engagement (i.e., at the early stage of technological development) might transform traditional risk communication into more active participation in the decision-making process on behalf of public representatives (Evers & D'Silva, 2009).

In the case of cloning, current cost issues and technical challenges dictate that only elite animals, which are to be used as breeding stock, have been initial targets for farm animal cloning (Faber, Molina, Ohlrichs, Vander Zwaag, & Ferré, 2003; Wall et al., 2009), but there is no current consensus regarding the commercial viability of this. Estimated costs in the region of $13,000 to $17,500 (Oosthoek, 2008) can only be accurately interpreted against the net value proposition to the end consumer. Regardless of such issues, the results of this work would indicate that Ireland does not appear to be ready to compete on a technological footing in this area, and is likely to adopt a reactive "watching brief" position rather than take a proactive stance. Such an approach would not rule out possible access to cloning technology in the future, for example, through technology licensing.

A key question will relate to public response locally and globally. In this regard, the absence of an outright rejection of cloning technology on the basis of principle among many interviewees is noteworthy but cannot be easily extrapolated to anticipate the attitudes of the general Irish public. The preponderance of advanced scientific degrees among the participants attests to their explicit knowledge within their areas of expertise, which was partly the basis for inclusion in the study in the first place, and is evidence of their systematic training in logic. Conversely, the general public has relatively little knowledge about the food production process. Therefore trust is a key aspect (Siegrist, 2008). An additional inherent bias resulting from this study cohort may be a reluctance among many in this group to consider acceptance aspects of cloning that rely on tacit knowledge such as spiritual belief or those relating to cultural and psychological factors (reviewed in Finucane & Holup, 2005). Such unsympathetic perspectives are evident in the biotechnology literature (see for example, Miller, 2007), and the views of some of this study cohort regarding functional foods might be reflective of this. Work is currently underway to assess the wider applicability of these findings to potential consumers of cloned food produce, by using focus groups to further dissect the salient issues.

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