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Cattle breeding in Northern Australia: Revealing how consumers react to alternative technologies[1]

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Abstract

In Australia, *Bos taurus* cattle breeds produce high quality meat, superior in taste and tenderness characteristics. Nevertheless, these breeds do not thrive in the Northern Australian environment. Stem cell transplant technologies, that make use of adult stem cells harvested from a *Bos Taurus* bull and the subsequent allogeneic transplantation of testicular cells into a *Bos indicus* bull, could improve northern beef cattle breeding programs by facilitating crossbreeding via natural service. Focus groups were used in this study to explore consumer reaction to specific reproduction technologies and the implications for buying intentions. Findings from these focus groups were then used for development of choice experiment surveys. Survey results suggested that while some consumers indicated that they were not concerned about the specified stem cell technology being utilized in beef production, generally people were willing to pay to avoid eating steak that had been produced in this way. Moreover, it appears that they would pay more to avoid this steak when specific key words providing additional information about the technology (stem cells; radiotherapy) were used to describe the steak being valued. Even so, the wording of the technology description did not have a significant effect on this value. The relatively large discount values required by respondents to purchase steaks produced using stem cell technology may be slightly lower depending on whether consumers have a genuine aversion to the use of artificial insemination. It is beyond the scope of this study to explore the stability of preference estimates from a discrete choice experiment but from a theoretical perspective, it would be worthwhile.

Key words: Non-market valuation, consumers, focus groups, breeding alternative technologies, beef

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Introduction

Standards of livestock husbandry and the welfare of animals in livestock production systems are becoming increasingly important factors influencing customer perceptions of animal products (Strom 2006; Fisher 2006). For animal breeding research and selection decisions to be appropriate, uniting biological and socio-economic research can address how consumer attitudes, towards foods of animal origin, animal welfare, traditional practices, regional distinctiveness and price, influence their purchase decisions over time (FABRE 2006).

FABRE's (2006) proposal that there is a need for research on reproduction technologies required to underpin breeding as well as the effective dissemination of genetic improvement for all producers is of specific relevance to this paper. Even so, from an ethical and transparent perspective, as viewed by authors such as Neeteson-van Nieuwenhoven *et al.* (2006) and Gamborg *et al.* (2005), breeding procedures, natural or artificial, that cause or are likely to cause suffering, injury or distress to any animals involved should not be put into practice. Even so, Gamborg *et al.* (2005) suggested activities associated with breeding that cause minor or momentary suffering (e.g. natural delivery or embryo transplantation) should not be part of this provision.

Artificial insemination (AI) is established in many livestock systems as a central method of animal reproduction with an essential role in breeding programmes and genetic dissemination (FABRE 2006; Foote 2002). In the initial stages of attempting to develop AI there were several obstacles including opposition from the general public who were against research that had anything to do with sex and associated with this was the fear that AI would lead to abnormalities (Foote 2002). The knowledge gained from the AI experience and the gradual acceptance of AI technology worldwide provided the impetus for developing other technologies such as cryopreservation, sexing of sperm, estrous cycle regulation, embryo harvesting, freezing, culture and transfer, and cloning (Foote 2002).

In the temperate climatic regions of southern Australia *Bos taurus* cattle breeds produce high quality meat with superior taste and tenderness characteristics. Nevertheless, as explained by Bindon and Jones (2001) these breeds are unlike the *Bos indicus* genotypes that are productively efficient (e.g. tick and worm resistance) in the difficult environments of the tropical regions of northern Australia. Using artificial insemination, as elaborated upon by Foote (2002) whereby sperm from *Bos taurus* bulls could be used to impregnate *Bos indicus* cows adapted to the region, is one way to introduce *Bos taurus* genes into the herd. However, mustering cattle to enable application of this procedure is difficult in rangeland farming in Northern Australia (Foote 2002; Herrid *et al.* 2006; Hill and Dobrinski 2006) and hence germ cell transplant techniques could fill a niche in such beef cattle operations by facilitating crossbreeding or introduction of new genetics via natural service.

Herrid *et al.* (2006) concluded that allogeneic transplantation of testicular cells can successfully occur between *Bos taurus* and *Bos indicus* cattle. The transplantation technique uses adult stem cells harvested from a donor animal. Firstly, the host animal is given a low dose of radiotherapy to incapacitate its normal sperm production. The donor stem cells are then injected into the seminiferous tubules where they migrate from the lumen to relocate to the base membrane and there retain their capacity to produce donor sperm in the new host (Hill and Dobrinski 2006). Being an alternative to AI in the cattle industry, in areas where AI is not practical (Hill and Dobrinski 2006), this research aims to raise the performance of Australia's northern herd (18 million *Bos indicus*) by enabling mass production of *Bos indicus*/*Bos taurus* hybrids (CSIRO 2008).

Changes in production techniques that influence on-farm costs can clearly be evaluated by farmers. Some production traits and improved food quality may increase the *market* value of the product, in ways that are known and hence can be priced. However, some consumer concerns may lack an immediate market value (Gamborg *et al.* 2005), or be difficult to evaluate and so require innovative methods of evaluating consumer preferences. This is likely to be the case where the effect is novel, or not well understood by consumers. In the case of animal welfare, evaluating consumer preferences is particularly pertinent because as Frewer *et al*. (2005) alluded to, animal husbandry techniques that do not meet with the approval of consumers may not succeed commercially.

To gain some understanding about consumers' perceptions of this alternative production process to produce 'novel crossbred' beef, Mireaux *et al.* (2007) found that consumers placed an equal ranking on

'novel crossbred' beef and Brahman beef produced by conventional breeding methods. However, their findings also indicated that despite age and gender, consumers would be significantly more likely to buy the 'conventional' beef over the 'novel crossbred' beef with no significant differences between gender or age groups. How 'high' or 'low' the price would have to be before consumers change their desire to purchase the product was not investigated in this study.

Lagerkvist *et al.* (2006) examined consumers' preferences for immunocastration in pigs by comparing willingness-to-pay estimates obtained from a choice experiment by having consumers trade off price and product attributes characterized by various levels of animal welfare, taste quality, and use of biotechnology in pork production. They found that people seemed to accept potential food safety risks to alleviate animal welfare problems related to surgical castration, but they preferred pork from surgical castrates over pork from intact boars indicating that taste quality as a product attribute dominates over animal welfare concerns.

This study aims to determine if the description of reproduction technologies, and in particular stem cell technology, used in beef production influences consumers' buying intentions. It extends the findings of Mireaux *et al.* (2007), using focus group methodology as described by Hartman (2004) and choice experiments, similar to Lagerkvist *et al.* (2006). The paper is divided into three parts. Part I details the experimental design, Part II outlines the model and Part III reports the methodology and results from the choice experiment. Conclusions are drawn in the final section.

Part I: Experimental design

Methodology

Focus groups were conducted to explore people's perceptions of words and phrases used to describe the production technology and attributes to be used in the choice experiments. A questionnaire based on focus group findings was constructed and tested in an on-line pretest to further test the technology descriptions and the delivery mechanism before the main survey was completed.

The first focus group session was held in May 2008 with the aim being to gain a better understanding about how consumers view meat purchases and how they react to various descriptions of reproduction technologies in livestock production. To further explore people's reactions to stem cell technology used in beef production and descriptions of specific words (e.g. stem cells), a second focus group was conducted in June 2008. Eight people were selected for each group.

Results and discussion

Participants in Focus Group 1 had varying perceptions about 'meat' depending on how they intended to cook it and who it was for. Therefore in developing the choice experiment questionnaire, people were asked to value meat that was specifically defined as '*their usual beef steak*'. Also participants did not necessarily think in terms of price per kilo and hence in the questionnaire it was clearly stated in the valuation question that the question pertained to the '*price they paid for their usual beef steak in $/kg*'. In line with findings from Alfnes (2004) and Carpenter *et al.* (2001), participants placed importance on quality characteristics of the meat and gave little thought to the production process. Hence when constructing the questionnaire, the attributes were clearly explained so that all survey respondents had the same basic knowledge about the production technologies of interest. In addition, participants in the focus groups mentioned some ethical concerns with e.g. free range chickens and the treatment of animals in general and so basic welfare information stating that production '*meets animal ethics and welfare guidelines*' were included in the questionnaire. Overall as a result of this activity, questions were restructured and additional ones added to improve data collection in the final questionnaire as described in Part III below.

Generally the findings from the first focus group indicated that consumers had enough knowledge and experience to value meat with different attributes but the technology descriptions needed rewriting to remove some ambiguity. Further, '*radiotherapy*' was linked negatively with cancer treatments and so it was decided to include in the survey a version of the technology description that included the term '*radiotherapy*' and others that did not. These descriptions were developed to differ in terms of the use of

certain keywords thought likely to trigger strong and/or emotive responses. When discussing animal breeding the main focus was on genetic modification, which was viewed negatively. Hence it was decided in the technology descriptions for the survey to include an explanation stating that this process is not genetic modification; "*Note that these cattle and the meat from them are not classified as genetically modified or GM food*".

As in Focus Group 1, participants in Focus Group 2 did not spontaneously think about how the meat they eat was produced. This was largely because they felt that meat in Australia was 'safe'. Participants also raised concerns about connections between words such as '*embryos*' and '*stem cells*' and they found it difficult to understand that '*adult*' stem cells did not necessary come from an adult being. It was therefore decided in the technology description for the survey to leave out any reference to '*embryo*' or '*adult*'.

Part II: The model

Findings from the focus groups were expanded upon to develop choice experiment questionnaires. Hensher *et al.* (2005a) provide an overview of the choice experiment (CE) approach, with Rigby *et al.* (2004) providing an example of an application to a novel food technology. Essentially with the application of CE, individuals can choose between alternative options that contain a number of attributes (one being a price term) with different levels. Respondents are not asked to report how much they prefer alternatives, nor how much they value individual changes in an attribute but only to identify which of the options they prefer. Each respondent in the sample is offered a number of such choice sets and after providing a response for each, it is possible to isolate the effects that variations in individual characteristics have on changes in the price term (i.e. it is possible to estimate the monetary trade-offs between price and each of the other characteristics describing the option).

Hensher *et al*. (2005a) explain choice experiment methodology as being based on random utility theory whereby individual consumers choose alternatives that yield the greatest utility and so the probability of selecting an alternative increases as the utility associated with it increases. The option with the greatest welfare from its level of attributes is chosen by the individual. The model is given empirical content by explicitly modelling the process by which welfare is generated and in its simplest form can be specified as:

$$U_j=\beta_1 TECH_j + \beta_2 PAY_j + e_j \quad (1)$$

where U_j is the utility obtained by an individual from option j; TECH is a dummy variable used in this example to indicate the use of conventional or alternative technology and PAY is the price paid for the product; β_1 and β_2 are parameters to be estimated.

Hensher *et al*. (2005a) further explain that the individual parameters generated by the model do not have a numerical interpretation (they are the scaled marginal utility of an attribute, where the scale is determined by the error variance), other than in their signs or statistical significance. However, the parameters can be combined to identify monetary values associated with changes in each attribute level. Consider Equation 1, a shift from conventional to alternative technology, *ceteris paribus,* will change utility by an amount β_1. How much the consumer would be willing to pay to attain the subsequent level of utility, may be explained in the notion of a 'partworth'. This is the change in the price of steak, x, which would leave the consumer indifferent between the old steak, without the innovation and a new steak with it. This can be derived by equating the utility with and without the new technology i.e. solving:

$$\beta_1*[TECH=1] + \beta_2 (PAY_i+x) = \beta_2 (PAY_i) + \beta_1*[TECH=0] \quad (2)$$

where, in terms of Equation 2, $TECH_j = 0$ denotes the choice with conventional technology and $TECH_j = 1$ denotes the choice with alternative technology and PAY_i is the initial price.

This can be solved to give an expected value (x) of the innovation:

$$x = -\beta_1/\beta_2 \quad (3)$$

x is the partworth associated with a unit increase in the attribute. If in this example β_1 is negative the presence of the alternative technology will reduce the probability that the option will be chosen. One would expect β_2 also to be negative (i.e. options with higher payment levels will be less likely to be chosen), and hence the partworth as a whole will be negative (Hensher *et al*. 2005a). In this case the

partworth would be interpreted as the maximum that the respondent would be willing to pay for 'conventional' steak to avoid consuming the alternative steak. If an innovation is valued as positive to the consumer, the partworth will be positive and represent how much more the consumer is willing to pay to consume a steak with that characteristic. One can generalize equation (1) so that there are multiple attributes being considered at once.

Part III: The choice experiment

Methodology

In this study there were four questionnaires, each differentiated by a different description of the technology. The first version (A) included the key words, 'stem cells' and 'radiotherapy', the second version (B) referred only to 'stem cells' omitting 'radiotherapy' while the third (C) did not mention either term but instead referred to a 'treatment' for cattle. The remaining version (D) focused on artificial insemination rather than stem cell use. In each of these four treatments the reproductive technologies represented an alternative to the conventional reproductive technology (see Appendix for descriptions). Respondents were asked to make choices between steaks (see Figure 1 for an example of a choice question) that differed in terms of the following 'attributes': reproduction technology used; whether the cattle were finished in the "paddock" or "feedlot"; state of origin for the beef production; price of the beef (see Appendix for descriptions). They were reminded that taste, texture and appearance of all steaks were the same as their usual steak. The purpose of consumers making these choices was to find if respondents have particular preferences with respect to any of the attributes and if so, why. For example, do they prefer steak produced using conventional technology or the alternative technology and is price the most important factor in their decision to buy steak? In making these choices the respondents are implicitly trading off between these attributes. Respondents were also asked to consider attitudinal, behavioral and knowledge questions.

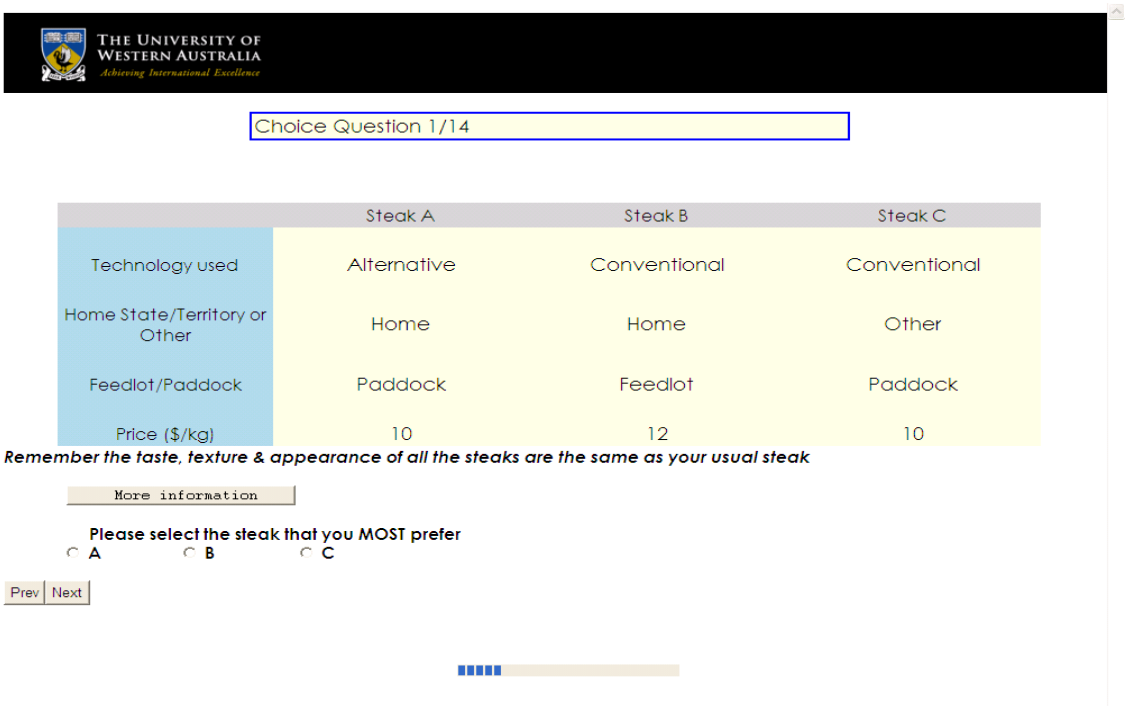

Figure 1: A typical choice set that a respondent would consider in the on-line questionnaire.

The Online Research Unit[2] (ORU) was selected to distribute the questionnaires during September 2008. A random sample of people who participate in on-line research facilitated by ORU was invited to take part in this survey. Before the main survey was undertaken, a quota of 50 respondents for each information-set was used as a full on-line pretest of the survey.

The questionnaire for the on-line pretest was successfully distributed by ORU and within three working days the participant quota was filled and the data was immediately ready for processing. Data obtained from the survey indicated that respondents generally understood the questions and responded to them in a consistent manner. Whether respondents were given the description of a reproduction technology with reference to stem cells or not, all were asked if they had heard about stem cells. A quarter indicated that they have heard about the use of stem cells in food production. The questions for the main survey were reviewed as a consequence to collect data pertaining to respondents' understanding of stem cells with and without prior information. The questionnaire pre-test results indicated that the on-line procedure was an effective means to collect the survey data, with no adverse responses from respondents.

The main survey was conducted as for the on-line pre-test. The data collection was conducted in mid-December 2008[3]. Potential respondents were invited to complete the questionnaire and when the required sample size (250 for each of the treatments) was reached the survey was closed. Allowing for a predicted loss of survey participants due to filtering because they didn't buy meat, this sample size was sufficient to estimate the separate models. As for the pre-test, the experimental design was made up of four treatments with the questionnaire for each having a unique description of the new breeding technology (Versions, A, B, C and D as in the Appendix). Again each of the technologies was related to the way steak is produced and respondents were then asked to consider a choice set and make choices between the steak they eat after considering the 'attributes'. Respondents were also asked to consider attitudinal, behavioral and knowledge questions.

Results and Discussion

The demographic profile of the survey sample appeared to represent the general population, with respondents from all Australian States and Territories (Figure 2), of all age and education groups, and with an even distribution of gender (for more detail see Pluske *et al.* 2009).

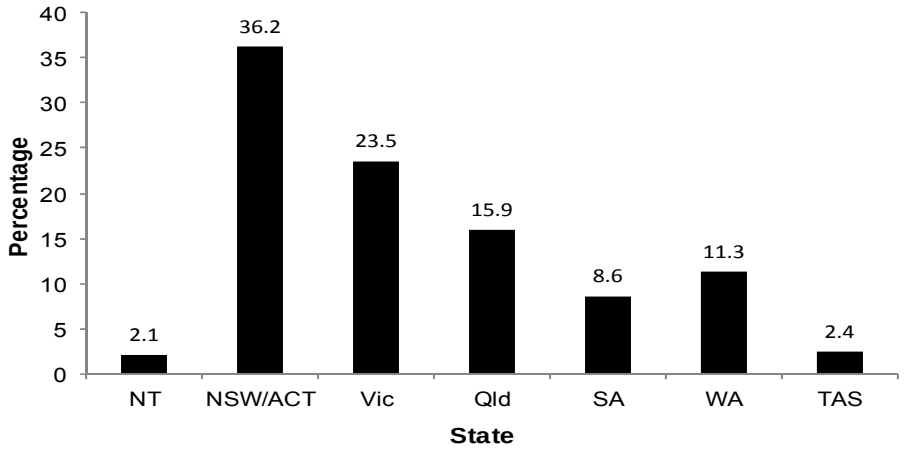

Figure 2:Percentage of respondents from each State/Territory

[2] ORU own and manage the largest research-only proprietary online panel in Australia with 300,000 members. They comply with all local (AMSRS) and international (ESOMAR) guidelines for online panels.

[3]Other analysis using this and a subsequent 2009 sample have investigated issues of attribute non-attendance and self selection of complexity in this context: see Balcombe *et al*. (2011), Burton and Rigby (2012)

Respondents were asked at the beginning of the questionnaire if they purchased meat. Three per cent of respondents didn't buy meat and at this point they exited the survey. A total of 968 respondents (filtered) completed the questionnaire.

Forty per cent of respondents had recently heard or seen something about the use of stem cells in food production (n=968). Of the 239 respondents who completed a questionnaire with AI being the focus of the technology description (Version D), 72 per cent were previously aware that this technology is being used in some beef production enterprises. By comparison, of the total respondents in the survey only 54 per cent were previously aware that beef that they eat might have come from cattle that have spent time in a feedlot. This is despite the fact that the standard, domestic beef supply chain in Australia involves beef produced from both grass and feedlot situations (Gong *et al.* 2007).

These findings concur with those in the literature. van Eenennaam (2006) presented findings from a survey indicating that half of the participants had never heard about traditional livestock crossbreeding schemes, and this widely used breeding approach received only a 31 per cent acceptance rating with 50 per cent of the respondents indicating that they considered the crossbreeding of animals to be morally wrong. This finding is in line with that of Bruhn (2003) who found that less than 40 per cent of survey respondents indicated support for traditional crossbreeding practices while more than 40 per cent supported the use of biotechnology to produce leaner meat, or enhance animal disease resistance. While the author questions consumers' knowledge of livestock production practices it is possible that consumers may have a different opinion when the emphasis is on the food product as opposed to the production practice. Aldrich and Blisard (1998) noted that a large proportion of consumers disapprove of traditional cross-breeding but this does not necessarily mean refusal to purchase milk and meat from common farm animals.

If the cut of steak that respondents normally buy was labelled as being produced from beef bred using AI, just over 60 per cent indicated that it was likely that they would purchase that steak. Around 12 per cent suggested that it was unlikely that they would buy steak if they knew it was produced using AI technology (Figure 3). This finding is in line with that reported by Gamborg *et al.* (2005) who found that most people felt that reproduction techniques such as artificial insemination and freezing of semen were considered acceptable.

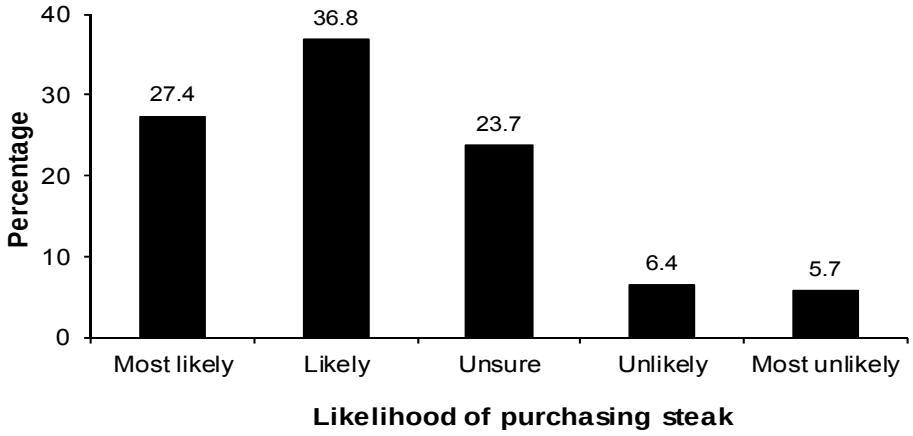

Figure 3: The percentage of respondents who were likely or not to purchase steak that had been produced using AI technology (n = 296).

Almost half of the respondents were not concerned about the use of stem cells in cattle breeding while around 30 per cent were a little concerned. Approximately 20 per cent were concerned about the use of

this technology (Figure 4). This attitude seems to be similar to that of American consumers who are generally not so concerned about how food products (or their ingredients) were developed (Hoban 1998). Further Hoban (1998) suggested that as with foods in general, people are primarily concerned with how food produced using biotechnology tastes and how much it costs as well as nutrition, safety, and cooking techniques.

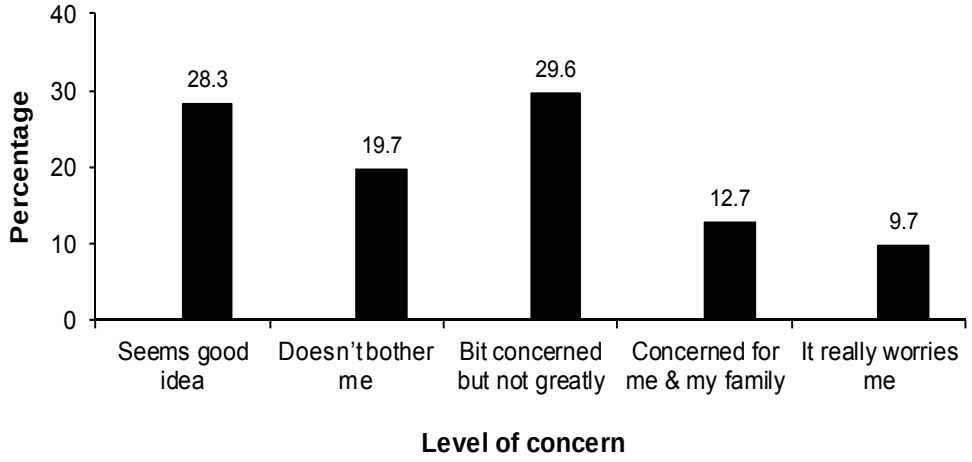

Figure 4: The percentage of respondents who were concerned or not about the use of stem cells in cattle breeding (n = 558).

Of those people who were concerned about the use of stem cells in beef production, most were worried about food safety, the food production process being unnatural and using excessive technology. Fewer people had concerns about animal welfare issues (Figure 5). This finding is not surprising considering that Frewer *et al*. (2005) found that consumers were less likely to consider the details of animal production systems when making decisions about the acceptability or otherwise of animal welfare practices. They also noted that consumers may actively avoid information pertinent to animal welfare and meat production.

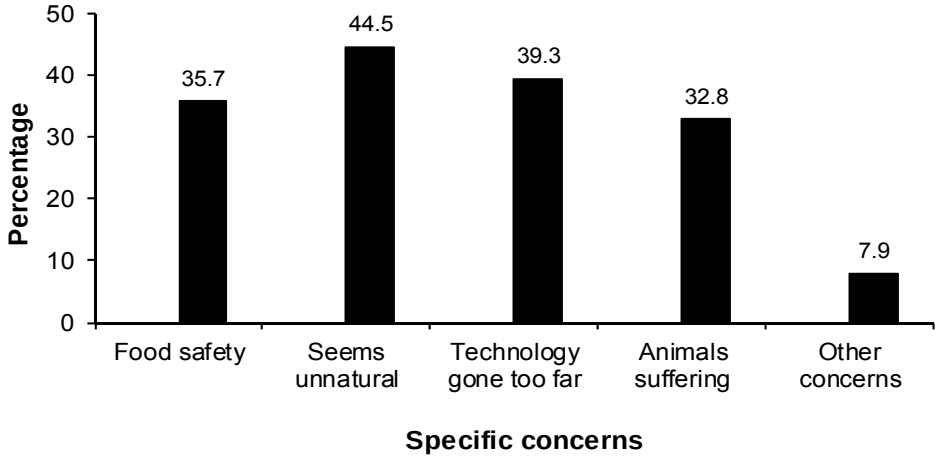

Figure 5: The percentage of respondents who indicated the reason/s for their concern about the use of stem cells in cattle breeding (they could choose more than one reason) (n = 290).

To find which parameters reduced the welfare of respondents, heteroscedastic-conditional logit models were estimated pooling the data for all four technology definitions. The advantage of pooling data is that one can formally identify whether the difference in the technology descriptions is having an impact on marginal utilities for the attributes, with the introduction of interaction dummy variables, *VB*, *VC* and *VD* associated with technology definitions B, C and D respectively. The problem with pooling data is that one can conflate differences in the error variances in the different data sets with differences in marginal utilities (Swait and Louviere 1993; Hensher *et al.* 1999). Heteroscedastic-conditional logit models control for differences in error variance by introducing 'scale' parameters (inversely related to variance) which can be estimated. Estimation is conducted within Stata (using clogithet, written by A.R. Hole). The scale parameter estimates indicated some differences in error variance across the four technology descriptions, with Version D (the AI technology version) having a significantly smaller error variance (i.e. significantly larger scale) compared to the other three versions (Table 1).

Table 1: Heteroscedastic-conditional logit models, testing for Technology Description effects.

Variable	Coefficient
price	-0.100***
tech	-0.592***
VB*tech	0.001
VC*tech	0.150
VD*tech	0.415***
origin	-0.249***
VB*origin	-0.125
VC*origin	0.061
VD*origin	-0.003
feed	-0.842***
VB*feed	0.042
VC*feed	0.168
VD*feed	0.303***
Scale parameter	
VB	-0.263*
VC	0.215*
VD	0.253**
Observations	11136
Number of groups	3712
LL Value	-3532.91
*** p<0.01, ** p<0.05, * p<0.1	

In all cases, a higher price, the alternative technology, origin other than home State and finishing in feedlots were seen to reduce welfare of the respondent. The interaction terms between version dummies and attributes indicated the extent to which the value attached to the attribute varied across versions. Of central interest was the change associated with the technology description. Somewhat surprisingly, there was no estimated difference between questionnaire Versions B (stems cells were mentioned in the technology description) and C (stem cells were not mentioned in the description) compared to the base case of Version A, that had the full technology description including stem cells and radiotherapy. This suggests that for this sample, the wording did not generate additional concern. The coefficient associated with *VD*tech* was positive, suggesting that respondents were less concerned about the AI description compared to the stem cell technology descriptions, although the net coefficient was still negative (-0.177).

There was no difference in value placed on the origin of beef across the four versions (none of the interactions were significant), which might have been expected, and similarly with the feedlot variable, there was no difference between the versions containing the words stem cell. However, there was a

difference between the technology versions with stem cell and the AI version of the survey, with respondents less concerned about the use of feedlots within the latter version.

This suggests that the description of the technology is having flow-over effects into consideration of the other attributes, which one might otherwise consider to be independent. That is, the results suggested that the stem cell technology has sensitised respondents to levels of other attributes.

Although the estimated parameters report sign and significance of effects, they do not have any direct economic interpretation. For that reason it is necessary to estimate the willingness to pay (WTP) to acquire the attribute. This is defined by the (negative) ratio of the attribute parameter to the price parameter. A positive value for this effect implies that the respondent would gain an increase in utility from a unit increment in the attribute, and the dollar estimate is the largest amount that they would be willing to pay for that attribute. A negative value implies that the attribute is utility reducing and hence they would require monetary compensation before they would willingly purchase it. In the case where the attribute is defined as a dummy variable, indicating presence/absence of a feature, the WTP amounts indicate the amount respondents would be willing to pay (or require in compensation) for the presence of that attribute in the good.

Table 2 below reports the WTP associated with each attribute, for each of the technology descriptions. In all cases these WTP values were significantly greater than zero, at the 99% level. The results suggested that people given descriptions of steak production that included key words associated with using the stem cell technology would require a discount of approximately $5.90. However, respondents presented with a generic description of the technology would require a discount of $4.40. Although there is a slight numerical difference, the WTP values were not statistically different across the three versions of the description of the stem cell technology. However, there was a statistical difference (at the 1% level) between the discount required when respondents considered the technology descriptions for Versions A and D, the alternative technology (Table 2).

Table 2: Estimated willingness to pay associated with attribute presence with a steak ($/kilo).

	Version of the Technology Descriptions			
	A	B	C	D
	Stem Cell + radiotherapy	Stem Cell only	Generic new technology	AI described as alternative technology
Alternative technology	-5.90	-5.89	-4.40	-1.77 ***
Origin: out of state	-2.48	-3.72	-1.88	-2.51
Finished in feedlot	-8.38	-7.96	-6.70	-5.36

All WTP values significantly greater than zero ($p<0.01$)

*** indicates statistical difference from WTP for technology given description for Version A ($p<0.01$)

FABRE (2006) and Neeteson-van Nieuwenhoven *et al.* (2006) suggested that transparency about new technological developments, clear definitions of terminology and an open dialogue with society are important for all stakeholders. Further, Mireaux *et al.* (2007) noted that the information provided to respondents when making trade-offs is likely to have an effect on their choices. While IFIC (2007) surmised that this leads to greater acceptance of such technology it would seem that this was not the case in this study. This discount value for steak produced using stem cell technology is perhaps sizable

considering that data collected at the beginning of the questionnaire indicated that 'normal' beef steak costs on average $14 per kilogram. Even so, the AI technology, as described in the questionnaire, induced respondents to require a $1.77 discount.

There are two interpretations of this value. The first is that it is a study induced effect: having it presented in the study as an alternative technology generates the inverse of a "warm glow" effect: an aversion that is not present in actual behaviour, but induced by the experimental framework where the technology is highlighted. If that is the case, then one could use it as a basis for reducing the estimated discount associated with the stem cell technology. The alternative is that it represents a genuine aversion to the use of AI, one that is not manifested through markets because of the lack of labelling. Further work to identify segments within the population that hold these values would be useful.

In addition, one might raise an issue about the extent to which the technology attributes are actually 'fungible', in the sense that respondents are prepared to tradeoff concerns about welfare for a sufficiently high level of compensation. Hess *et al.* (2012) conducted a stated choice experiment designed to test the fungibility and consistency of monetary valuations in transport and specifically trade-offs between travel time, travel cost, and safety. While they noted that there were limitations in their study, they found that time was valued more highly when valued directly by cost than when traded with safety, and the reverse was true for safety, suggesting that the assumption of fungibility did not hold. Moreover, Rigby and Burton (2006) identified segments of a sample where the implied size of the discounts required to consume GM foods would suggest that, for those individuals, the attribute is not fungible in a meaningful way. However, the estimates of discounts presented in this paper, although relatively large, suggested that this analysis did not reveal a major problem in this area.

Conclusions

The process of using focus groups and pre-testing was important in this study so that the final attributes and technology descriptions used in the choice experiment were relevant to consumers. The level of detail and the use of words were also found in the focus group workshop to affect consumers' comprehension of the technologies and it was important to make sure these aspects were correct so that the effect of the 'key words' could be assessed in the main survey. In this project the focus groups provided valuable information that contributed to the design of the questionnaire for the main experiment.

Almost 1000 people responded to the main survey, with the population being from a wide range of demographics. Generally respondents were willing to pay to avoid any alternative technologies to those used to produce cattle in the 'conventional' way. Of those told about 'radiotherapy' and/or 'stem cells', around half had some level of concern about the technology.

While it is apparent that some consumers were not concerned about the use of stem cell technologies in animal production, generally people were willing to pay to avoid eating steak that had been produced using these technologies. However, the wording of the technology description did not have a significant effect on this value. The relatively large discount values required by respondents to purchase steak produced using stem cell technology could be reduced by the discount value found for steak produced using AI. However, this could only be done if consumers did not have a genuine aversion to the use of AI. Further work exploring these findings would be of value especially in studies where issues such as perceived safety and welfare contribute to value formation.

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Appendix: Descriptions for the attributes used in the survey

Introduction

Many people don't think about how the meat that they eat is produced. However, in this survey we would like you to consider the steak that you normally buy and how the cattle it comes from are raised.

Modern agriculture often involves management of how animals reproduce, and in this survey we will ask you to consider 2 alternative forms of breeding technology. We will label these:

"Conventional"

And

"Alternative"

"The Conventional" Method

Modern agriculture often involves management of how animals reproduce. Different breeds of cattle have different characteristics. Cross breeding, which has been used for centuries, allows useful characteristics of each to be combined in a single animal.

For example, Northern bred cattle used in beef production can cope with the sometimes harsh weather conditions in the north of Australia and produce meat of lower quality (it is mostly used to produce hamburgers or mince). Other breeds, used to produce steak, are suited to Southern Australia but cannot survive conditions in Northern Australia. Cross breeding the two results in cattle that can survive in the Northern environment and be used to produce steak.

This crossbreeding method is the most commonly used currently in the production of beef, and in what follows we will describe steaks from cattle bred in this way as "conventional".

The "Alternative" method (Version A)

Although cross breeding Northern cows with Southern bulls is possible, introducing Southern bulls into the northern rangelands has not been particularly successful because the conditions are too harsh.

A new reproduction method, that meets animal ethics and welfare guidelines, is being developed by CSIRO. Using this method cross breeding can be achieved without introducing Southern bred bulls into the northern regions. Firstly, the testicle of a Northern bred bull is treated with a low dose of radiotherapy to stop him producing sperm. Stem cells removed from a Southern bred bull can then be injected into the testicle of the Northern bred bull. The effect is that it now produces sperm resembling that produced by the Southern bred bull.

The result is that the Northern bred bull, which can survive the northern environmental conditions, fathers cross bred cattle that can be raised to produce steak.

Note that these cattle and the meat from them are not classified as genetically modified or GM food.

The "Alternative" method (Version B)

Although cross breeding Northern cows with Southern bulls is possible, introducing Southern bulls into the northern rangelands has not been particularly successful because the conditions are too harsh.

A new reproduction method, that meets animal ethics and welfare guidelines, is being developed by CSIRO. Using this method cross breeding can be achieved without introducing Southern bred bulls into the northern regions. Stem cells removed from a Southern bred bull can be injected into the testicle of the Northern bred bull. The effect is that it now produces sperm resembling that produced by the Southern bred bull.

The result is that the Northern bred bull, which can survive the northern environmental conditions, fathers cross bred cattle that can be raised to produce steak.

Note that these cattle and the meat from them are not classified as genetically modified or GM food.

The "Alternative" method (Version C)

Although cross breeding Northern cows with Southern bulls is possible, introducing Southern bulls into the northern rangelands has not been particularly successful because the conditions are too harsh.

A new reproduction method, that meets animal ethics and welfare guidelines, is being developed by CSIRO. Using this method cross breeding can be achieved without introducing Southern bred bulls into the northern regions. A Northern bull can be treated so that he produces sperm resembling that produced by the Southern bred bull.

The result is that the Northern bred bull, which can survive the northern environmental conditions, fathers cross bred cattle that can be raised to produce steak.

Note that these cattle and the meat from them are not classified as genetically modified or GM food.

The "Alternative" method (Version D)

Although cross breeding Northern cows with Southern bulls is possible, introducing Southern bulls into the northern rangelands has not been particularly successful because the conditions are too harsh.

A reproduction method using artificial insemination (or AI) , that meets animal ethics and welfare guidelines, enables cross breeding to be achieved without introducing Southern bred bulls into the northern regions. Instead of the bull and cow mating in the usual way, sperm is taken from the Southern Bred bull and refrigerated. It is then transported to northern Australia and inserted by a trained AI specialist into Northern bred cows in their own environment.

The result is that Southern bred bulls don't have to be introduced into the northern environmental conditions, but can be used to father cross bred cattle that can be raised to produce steak.

Note that these cattle and the meat from them are not classified as genetically modified or GM food.

Descriptions for the other attributes

As well as the way the cattle are bred, the steaks you are going to choose between vary in terms of 3 other characteristics

Which State/Territory the cattle are from (Origin)

This identifies whether the cattle are raised in YOUR home State/Territory, or OTHER State/Territory in Australia.

Whether finished on feedlots or in the paddock (Feedlot/Paddock)

Feedlots are a confined yard area with watering and feeding facilities where cattle raised on pasture are 'finished' on a diet of grain feed prior to slaughter or live export. Cattle stay in feedlots for periods varying from about 30 days up to about 300 days depending on the weight required by the particular customer.

Approximately 97% of all Australian grain-fed beef is derived from feedlots that work under the National Feedlot Accreditation Scheme to achieve quality assurance. This form of production has been used in Australia since the 1960s, and approximately 40% of domestically consumed beef comes from feedlots.

Cattle raised in a paddock eat native and/or sown pastures for feed. They stay in this environment until they are sold. The industry doesn't have a specific code of practice but it is expected that producers monitor the condition of cattle and vegetation and maintain a sustainable production system.

The cost of the steaks in $/Kg (Price)

The price of steak was based on the price that they nominated that they pay for the steak that they usually buy. In the program hosting the questionnaire, the nominated price was copied in as the base price and alternative prices were calculated.