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CONSUMER PREFERENCE FOR PST-SUPPLEMENT PORK

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Conjoint measurement was used to determine consumer preference for fresh pork produced with genetically engineered porcine somatotropin (pST). A preference model was constructed based on three pork attributes, degree of fat reduction, price, and production technology, which allowed for interactions between attributes to be estimated. Interview surveys were used to collect data in several shopping centres in three Australian cities. Respondents generally preferred leaner pST-supplemented pork, but only at fat reduction levels greater than those possible with conventionally produced pork, and at competitive prices.

Introduction

The Australian meat industry is facing changes in consumption patterns. Per capita consumption of red meat (beef, veal, lamb, and mutton) has fallen over the last several decades, while consumption of white meat (poultry and pork) has increased. Some theories advanced for the changing trends in meat consumption include: dietary consciousness (Piggott and Wright, 1992); effects of relative prices (Gardner, 1990); ageing population (CRESAP, 1990); and effects of non-price variables such as 'convenience' particularly in the case of poultry (Piggott and Wright, 1992).

Consumer awareness of the association of fat and cholesterol with health problems is becoming more widespread (Putler and Frazao, 1988). In Mullen and Wohlgenant's (1991) study on willingness to pay for lamb attributes, 23 percent of the respondents cited health reasons and concern about red meat as reasons for not consuming lamb.

Currently, there is an opportunity for expanding pork consumption with leaner pork produced with genetically engineered porcine somatotropin. Porcine somatotropin (pST) is a protein that occurs naturally in pigs. PST reduces fat storage and increases muscle development (lean) (Turman and Andrews, 1955). However, pST production declines rapidly as pigs mature. Through advances in genetic engineering technology, it

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is now possible to manufacture pST exogenously. Experiments have shown that market-age pigs supplemented with genetically engineered pST experience increases in growth rates between 13 to 22 percent; improvement in feed conversion of between 19 and 34 percent, and reduction in body fat of between 22 and 36 percent (Griffith and Morris, 1991).

Since pST is a naturally occurring, species-specific protein, no adverse effects are expected to come from consuming pST-produced pork. However, studies have indicated that consumers are wary of using genetic engineering techniques in the production of food.

Tavener (1990) summarised the results of a survey conducted by Couchman and Fink-Jenson of over 2,000 New Zealand residents regarding their opinions on genetic engineering. Respondents said their greatest concern over the use of genetic engineering was using it to produce meat products. Twenty seven percent said their main concern over eating genetically engineered meat was that it is unnatural.

The successful adoption of pST by the pig industry will depend on consumer acceptance. The overall objective of this study is to provide information on consumer preferences toward pST-supplemented pork. There are two specific objectives:

i(i) to determine consumers' attitudes toward using genetic engineering to manufacture pST; and

(ii) to determine consumer preference for various attributes of pork produced with/without pST so the trade-offs consumers make between attributes such as price, production technology and leanness can be observed.

Methods and Design

Data were collected for this study by face-to-face interviews in shopping centres of three cities: Perth, Sydney, and Brisbane.

Survey Design

The survey instrument comprised three sections. The first contained questions on consumer attitudes regarding the use of genetically engineered pST to produce leaner pork. The second section contained a conjoint experiment designed to measure consumer preference for fresh pork products with different characteristics (attributes in conjoint experiment terminology). The conjoint analysis technique was chosen because consumer purchasing decisions are generally based on a set of multiattribute rather than single attribute alternatives. The third section contained questions on the socio-demographics of respondents.

Conceptual Framework of Conjoint Measurement

In conjoint analysis consumer preferences are evaluated as a function of the attributes of a product. According to Payson (1994), conjoint analysis is similar to hedonic pricing methods of quality measurements where the estimated parameters represent the influence of the attributes on quality. The main difference between hedonic pricing and conjoint analysis is that the latter uses price as an additional attribute of a good rather than as a direct indicator of quality.

The discussion of the economic theory behind conjoint analysis can best begin with Lancaster's (1977) demand theory for measuring changes in product attributes. To elaborate on the conjoint model under the backdrop of Lancaster's theory for measuring changes in attributes, a necessary condition for this model is that the consumer utility (U) function be separable between the good in question and the composite good that represents all other goods. This implies:

$$(1) \qquad U = U\,[U(c),\, V(s)]$$

where c is a vector of attributes of the good in question and s is a scalar representing the composite of all other goods (Payson, 1994).

In conjoint analysis, as in Lancaster's demand theory, the consumer is required to make judgement on the purchase of only one unit of the good. Thus, if s is measured in dollar units and y and p are consumer's income and the price of the good, respectively, equation 1 can be re-expressed as:

$$(2) \qquad U = U\,[U(c),\, V(y - p)]$$

where $y - p = s$. Therefore a change in the attribute levels of a good changes utility.

In this study each product can receive a rating from one to six where one is least preferred and six is most preferred. If U^o is the utility of the least-preferred choice and U^* is the utility of the most-preferred choice, then the respondent's rating is related to utility as follows:

$$(3) \qquad r = (6\text{–}1)\,\frac{U - U^0}{U^* - U^0} + 1.$$

The steps taken to implement the conjoint experiment of consumer preference for pST pork in this study were: the selection of pork product attributes and their levels; construction of a set of pork product profiles for evaluation; specification of a model of preference; selection of an appropriate estimation method; data collection; and evaluation of results.

Attributes and Attribute Levels

Because products are treated as bundles of attributes in conjoint analysis, it is essential to select attributes which are the most influential in consumer decision making. It is also of great importance to determine the proper ranges of attribute levels (Green and Srinivasan, 1978).

In the case of the pork products for this study, the attributes chosen were the level of fat reduction, the price, and the technology used to achieve fat reduction. Fat reduction and price were chosen based on the results of past studies showing price and leanness as important factors in meat purchasing decisions (Halbrendt et al., 1991). Technology was chosen as an attribute because determining consumer preference for pST versus non-pST pork is the main objective of the study. Other attributes such as freshness, and appearance have also been considered important to consumers, and were held constant in this study by showing respondents laminated coloured photographs of fresh pork.

Attribute levels of fat reduction and price were determined by technological feasibility and market prices for pork, respectively. The range of fat reduction levels for pST pork (up to 40 percent) was determined by the results of various experiments administering pST to pigs (Griffith and Morris, 1991). The upper limit for fat reduction using current technology and selective breeding practices was 20 percent (Schinckel, 1988). The prices \$6.99/kg and \$8.99/kg were chosen based on the prevailing Australian price range at the time of the survey.

Construction of the Product Profile Set

Initially, two attribute levels for technology (pST or current), four levels for fat reduction (0, 10, 20, 40 percent) and two levels for prices (\$6.99/kg and \$8.99/kg) were considered. With that decision the experiment has a full factorial design of 16 (2 x 2 x 4) pork product profiles. To prevent the possibility of respondent fatigue in rating 16 profiles, it was deemed necessary to reduce the number of profiles to ten.

Four product profiles were easily eliminated (two 40 percent fat reduction profiles with current technology, and two zero percent fat reduction profiles with pST) based on the technical infeasibility of attaining 40 percent fat reduction using current technology, and the assumption that using pST must result in some level of fat reduction.

To reach the target number of ten product profiles, two further profiles of the 12 remaining had to be deleted. The D-optimality criterion was used to make this decision. Some of the advantages of using the D-optimality criterion are that it minimises the generalised variance of the parameter estimates and is invariant to changes in scale of the parameters (Box and Draper, 1971). The final design with the ten chosen product profiles is shown in Table 1.

TABLE 1
Hypothetical Pork Product Profiles

Profile Number	Percent Fat Reduction	Fat Reduction Technology	Price per Kilogram
1	0	Current	\$6.99
2	0	Current	\$8.99
3	10	Current	\$6.99
4	20	Current	\$6.99
5	20	Current	\$8.99
6	10	pST	\$6.99
7	20	pST	\$6.99
8	20	pST	\$8.99
9	40	pST	\$6.99
10	40	pST	\$8.99

Model Specification

Unlike most conjoint experiments in which the importance of the main effects of product attributes are emphasised, the model for this study was specified to include interactions among the attributes. Interactive models imply that there is variation in the dependent variable (rating) associated with two or more of the independent variables (product attributes) working together. Although results are easier to interpret, main-effects models could be misspecified and often do not provide as good a fit as models including interactions (Forthofer and Lehnen, 1981). The initial model with interactions includes the first ten terms of equation 4. According to Piggott and Wright (1992) the differences in consumer demographics, attitudes and behaviour are important for segmenting consumers for marketing purposes. However, they also state that aggregate consumer data segmented by socio-demographic variables might smother or distort changes in consumer preferences which occur amongst only some groups of consumers. When the model with socio-demographic variables (gender, primary shopper, age, income, city or education) was tested for differences in consumer preference ratings, the socio-demographic parameters were generally not significant indicating that this might be the situation that Piggott and Wright had noted. With the above sociodemographic variables not having an impact, an attitudinal variable relating to respondents' concerns regarding the use of genetic engineering to produce pST was included in the model. The particular question that was used to segment the model was whether the respondent was concerned with introducing pST genes to bacteria to produce pST. The model incorporating the concern variable was specified as follows:

$$
\begin{aligned}
(4)\ rating_j = {} & \beta_0 + \beta_1 pST + \beta_2 RED + \beta_3 RED^2 + \beta_4 pST{*}RED + \beta_5 pST{*}RED^2 \\
& + \beta_6 PRICE + \beta_7 pST{*}PRICE + \beta_8 PRICE{*}RED + \beta_9 PRICE{*}RED^2 \\
& + \beta_{10} CONCERN + \beta_{11} CONCERN{*}pST + \beta_{12} CONCERN{*}RED \\
& + \beta_{13} CONCERN{*}RED^2 + \beta_{14} CONCERN{*}pST{*}RED \\
& + \beta_{15} CONCERN{*}pST{*}RED^2 + \beta_{16} CONCERN{*}PRICE \\
& + \beta_{17} CONCERN{*}pST{*}PRICE + \beta_{18} CONCERN{*}PRICE{*}RED \\
& + \beta_{19} CONCERN{*}PRICE{*}RED_2
\end{aligned}
$$

where $rating_j$ = respondent's rating for product profile j; pST = dummy variable for technology, with 1 if pST is adopted and 0 if current technology is used; RED = level of fat reduction at 0, 10, 20 and 40 percent; PRICE = price for pork products at \$6.99 and \$8.99 per kilogram; and CONCERN = dummy variable, with 1 if concerned about the use of genetically engineered pST to produce leaner pork and 0 otherwise.

Data Collection

Australian consumers who eat pork products were surveyed using face-to-face interviews. Because the surveys were conducted in shopping malls, there was no sampling frame (e.g., telephone book or list of residents) from which to draw a random sample. However, an effort was made to obtain a representative sample by gathering knowledge about different geographical areas before choosing survey sites. Surveys were conducted in three large cities: Perth, Sydney and Brisbane, which are three of the top five Australian cities based on population. To achieve representative samples within shopping malls, surveys were conducted both on weekdays and on weekends because it was likely that weekday shoppers were not representative of the population. Each respondent was shown a card for each of the ten product profiles and asked to rate from a scale of one (least preferred) to six (most preferred). To make the rating process easier and to encourage respondents to use the entire scale, a two-step process was used. First, respondents were asked to arrange the cards into three stacks, most-preferred, somewhat-preferred, and least-preferred. In the second step, respondents rated the cards within each stack. The ratings assigned to each stack were: one or two for least-preferred; three or four for somewhat-preferred and five or six for most-preferred. Respondents were permitted to give products within stacks the same ratings. Five hundred and fifty seven useable surveys were collected between June and July of 1992.

GSK-WLS Estimation Approach

Conjoint experiments are usually repeated measures designs. In other words, the same respondent is asked to rate more than one product profile. The advantages of repeated measures are lower costs and variance reduction. It is generally less expensive to ask 500 people to rate ten product profiles than to ask 5,000 people to rate one product profile each. Also, even ignoring costs, 5,000 people would be more heterogeneous resulting in a likely loss of precision.

However, because measurements by the same respondent are apt to be correlated, an analysis of a repeated-measures study should take this into account. Ignoring the correlation structure may lead to inaccurate estimates, standard errors and tests. In this paper the weighted least squares approach (WLS) of Grizzle, Starmer and Koch (GSK) (1969) was used to correct for possible within-respondent correlation.

Results

Socio-demographics Responses

The demographic profile of respondents is presented in Table 2. Of the 557 respondents, 74 percent were the primary shopper for the household, and the majority of respondents were female (68 percent). Over half of the respondents lived in households with two to three members (52 percent). There was also a large majority of married or defacto respondents, totalling 60 percent. Fifty percent of the respondents were over 39 years of age. Twenty-eight percent of the respondents had completed secondary school, 19 percent had some tertiary education, and 21 percent had completed tertiary education. Sixty-one percent of the respondents who answered the income level question had incomes of over $25,000.

TABLE 2
Socio-demographics of Respondents for this Study

Socio-demographic Characteristic		Number	Percent	Total Number	Total Percent
Primary Shopper					
	Yes	410	74		
	No	147	26	557	100
Gender					
	Female	381	68		
	Male	164	32	557	100
Household Size					
	1	58	10		
	2	168	30		
	3	121	22		
	4	123	23		
	>5	87	15	557	100
Marital Status					
	Single	161	29		
	Married/Defacto	327	60		
	Divorced	31	6		
	Widowed	29	5	548	100
Age					
	15 to 19	52	10		
	20 to 24	56	10		
	25 to 29	57	11		
	30 to 39	100	18		
	40 to 49	127	23		
	>50	155	28	547	100

Table 2 (continued)

Socio-demographic Characteristic	Number	Percent	Total Number	Total Percent
Education				
Some Secondary School	92	17		
Finished Secondary School	50	28		
Some Tertiary Education	104	19		
Tertiary Educated	111	21		
Some/Completed Post-graduate School	36	13		
Other	13	2	542	100
Income				
<10,000	59	12		
10,000 to 14,999	43	9		
15,000 to 19,999	36	7		
20,000 to 24,999	59	12		
25,000 to 34,999	98	19		
35,000 to 49,999	110	22		
>50,000	101	20	506	100
City				
Perth	214	38		
Sydney	204	37		
Brisbane	139	25	557	100

Attitudinal Responses

Respondents were asked their knowledge and attitudes toward the manufacturing and use of genetically engineered pST. When asked if they had heard of the product pST, only 10.5 percent of the respondents answered that they had heard of it. The main source of information about pST was television and/or radio, followed by newspapers.

Before being asked the next set of questions, respondents were given a brief description of pST and how it is produced. The respondent was then asked to give his or her level of concern over the introduction of the pig's pST genes to bacteria in the production process of genetically engineered pST. Forty-eight percent of the respondents were concerned over this process, but 52 percent were unconcerned or indifferent.

Respondents were also asked if they were in favour of using pST based on the resulting leaner pork products or on potentially lower prices. In general, respondents said they were in favour of using pST if it resulted in lower prices or leaner pork. Fifty-three percent of the respondents strongly or somewhat agreed that they were in favour of using pST because it may lower the price of pork, but 75 percent said they strongly or somewhat agreed because it would result in leaner pork. Twenty-nine percent of the respondents strongly or somewhat disagreed with lower prices as a reason to use pST, but only 18 percent strongly or somewhat disagreed with leaner pork as a reason to use genetically engineered pST. The remaining respondents were indifferent).

Conjoint Experiment Results

Mean Ratings

In the conjoint experiment, respondents were asked to evaluate the ten products in terms of their preferences. The ten product profiles and their mean rating values are presented in Table 3. The product with the highest mean rating of 4.97 out of a possible 6 was profile nine, which was pST-supplemented, $6.99/kg, with a fat reduction level of 40 percent. The higher-priced profile ten with the 40 percent reduction level had the second-highest rating of 4.36. Profile 4, which was current technology, $6.99/kg, and 20 percent fat reduction, also had a fairly high mean rating of 4.18. Respondents considered leanness an important attribute to pork products. The 40 percent fat reduction pork products had the highest preference ratings. However, with only 20 percent fat reduction, respondents preferred the pork produced with current technology rather than with the genetically engineered pST. High-priced current technology pork had about the same preference rating as the low-priced pST-produced pork when fat reduction was 20 percent. The profiles with the lowest mean rating were those with the 0 percent fat reduction. These are profiles 2 and 1, and have preference ratings of 1.41 and 1.57, respectively. Aversion toward fat is confirmed by the Worsley and Crawford (1985) study which showed that 48 percent of the female respondents perceived the importance of trimming fat for health reasons.

TABLE 3
Mean Rating Values for Survey Product Profiles

Profile	Technology	Fat Reduction %	Price $/kg	Mean Rating	Std. Dev.	Std. Err.
1	Current	0	6.99	1.57	1.19	0.05
2	Current	0	8.99	1.41	1.04	0.04
3	Current	10	6.99	2.44	1.34	0.06
4	Current	20	6.99	4.18	1.29	0.05

Profile	Technology	Fat Reduction %	Price $/kg	Mean Rating	Std. Dev.	Std. Err.
5	Current	20	8.99	3.55	1.30	0.06
6	pST	10	6.99	2.12	1.13	0.05
7	pST	20	6.99	3.57	1.37	0.06
8	pST	20	8.99	3.02	1.26	0.05
9	pST	40	6.99	4.97	1.70	0.07
10	pST	40	8.99	4.36	1.67	0.07

Model Parameters

The weighted-least-squares estimated parameters are presented in Table 4. Nine of the ten parameters, excluding the concern-related variables were significant at the 99 percent confidence level, indicating the interactive model was well-specified. Consistent with economic theory, the price parameter estimate was negative, indicating an inverse relationship of price with preference. The estimated pST parameter alone was negative, suggesting pST has an adverse impact on product preference. However, when pST interacts with leanness and price, the overall effect was positive, indicating pST that could produce leaner pork at a competitive price increases the respondent's preference. The fat reduction parameters generally were positive, confirming that higher fat reduction translates to higher product preference.

The concern-related variables interacting with other attributes such as price and fat reductions are mostly not significant except for the two concern variables interacting with the use of pST to reduce fat (*CONCERN*pST*RED* and *CONCERN*pST*RED*^{2}).

Since the model has significant second order and interactive terms, the coefficients for the first order terms, i.e. β_1, β_2, β_6, and β_{10} cannot be interpreted adequately without them. The best way to interpret interactive models is with graphs. Figure 1 consists of two graphs, one for the unconcerned respondents and one for the concerned. The vertical axis represents preference rating and the horizontal axis represents percent fat reduction. In each graph the extreme prices ($6.99 and $8.99 per kilogram) are first plotted for both conventional and pST-produced pork. Preference ratings for intermediate price ranges may be estimated by interpolation.

For the unconcerned respondents the pST and conventional technology curves with the same price and fat reduction level almost overlapped. For the concerned respondents the pST and conventional technology curves are distinct from each other with the general tendency of having higher ratings for the products produced with conventional technology. The latter findings indicate that those consumers who are concerned with the use of genetic engineering techniques to produce pST will not be satisfied with pST-supplemented pork products, *ceteris paribus*.

TABLE 4
Conjoint Model Estimated Parameters with the Concern Variable [1]

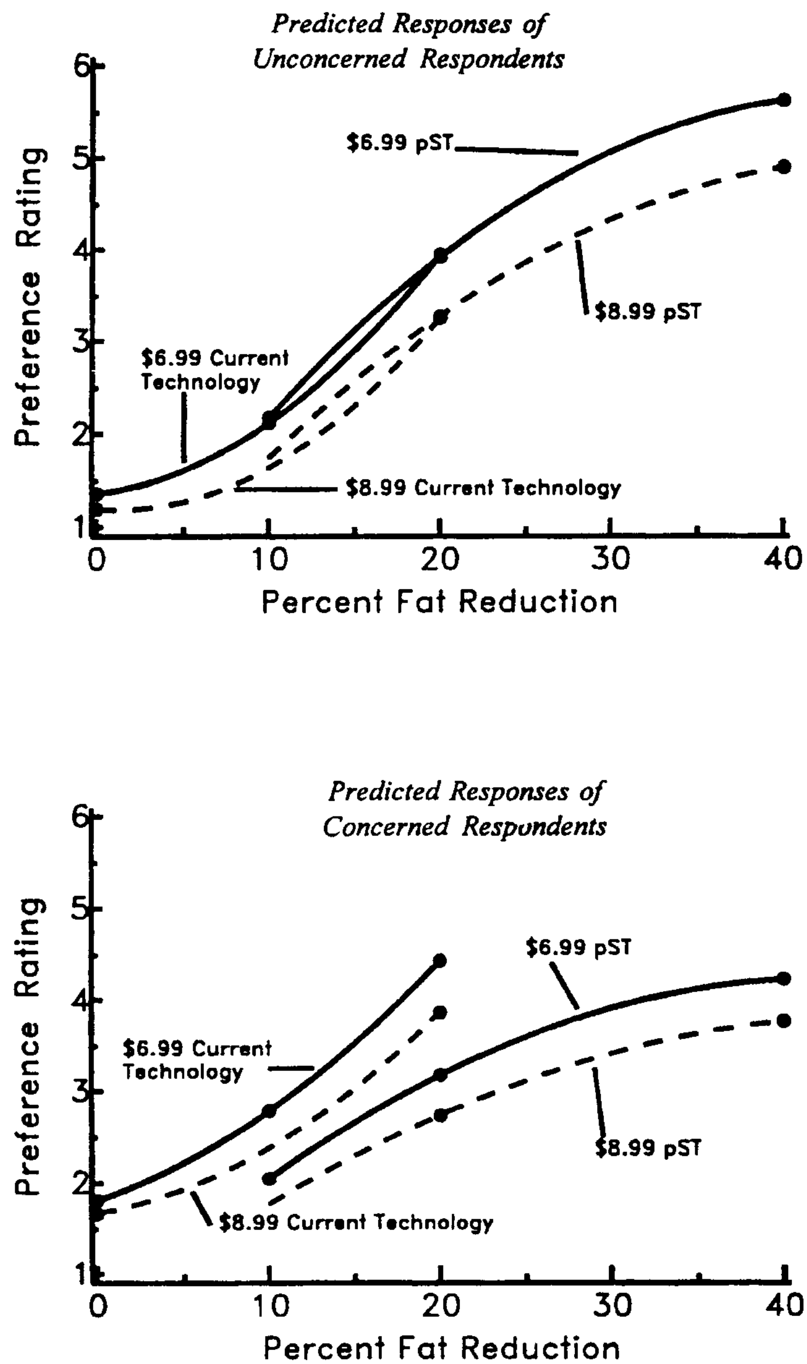
Parameter	Coef.	Std. Err.	Chi–sq.	*P*–value
INTERCEPT	1.931	0.185	108.43	0.000*
pST	–1.681	0.318	28.02	0.000*
RED	0.155	0.026	35.95	0.000*
RED^2	0.003	0.0007	22.24	0.000*
pST*RED	0.241	0.023	112.49	0.000*
pST*RED^2	–0.008	0.0007	130.31	0.000*
PRICE	–0.082	0.021	16.09	0.0001*
pST*PRICE	0.023	0.043	0.29	0.593
PRICE*RED	–0.019	0.003	35.56	0.0000*
PRICE*RED^2	0.0003	0.00007	15.99	0.0001*
CONCERN	0.380	0.288	1.75	0.186
CONCERN*pST	–0.063	0.488	0.02	0.897
CONCERN*RED	0.019	0.039	0.23	0.635
CONCERN*RED^2	–0.002	0.001	2.40	0.121
CONCERN*pST*RED	–0.132	0.035	13.86	0.0002*
CONCERN*pST*RED^2	0.003	0.001	6.27	0.012*
CONCERN*PRICE	0.011	0.032	0.11	0.743
CONCERN*pST*PRICE	0.041	0.064	0.40	0.525
CONCERN*PRICE*RED	0.003	0.047	0.49	0.483
CONCERN*PRICE*RED^2	–0.00003	0.0001	0.10	0.748

* Implies significance at the 0.05 level

[1] A test of significance en bloc was performed for the terms involving the concern variable. The resulting chi-squared value was 97.22, with an associated p-value of less than .001. Hence, concern is an important part of the model, even though eight of the ten concern-related variables are not significant.

FIGURE 1

Illustrations of Product Profiles Preference Segmented by Unconcerned/Concerned Respondents



Conclusions

The results of this study show that respondents are likely to accept pST-produced pork at the higher fat reduction levels with competitive prices. This is clear for the unconcerned respondents. For the concerned respondents it seems likely that some combinations of lower price and higher fat reduction should make pST- produced pork regarded as equal to conventionally produced pork (although deriving this from the model is inappropriate because prices lower than $6.99 are outside of the range of the model). However, the occurrence of lower prices for pST-produced pork seems feasible because pST could lead to lower production costs that could be passed on to consumers. A critical issue for the future success of pST-produced pork is how it is labelled and presented to the public. If consumers are not biased against pST , the purchase decision is likely to be based on price.

It is likely that the successful commercialisation of pST will depend to a considerable extent on government regulation of pST labelling requirements and on consumers' faith in the scientific community. It is probable that if labelling was not required, the chance of a successful use of pST would be much greater.

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