EFFECTS OF VARIOUS EATING QUALITY PATHWAY FACTORS ON PORK QUALITY
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Executive Summary

The Australian pork industry has relatively underdeveloped systems for the systematic prediction of pork eating quality. Only a few studies (Channon *et al.*, 2001; D'Souza and Mullan, 2002; D'Souza *et al.*, 2003) have investigated the importance of production and post-slaughter factors on the eating quality of Australian pork and information obtained was not integrated into an eating quality system. The majority of eating quality research conducted on pork has not been conducted with a pathway approach in mind and few studies have reported effects of interactions for factors investigated. The objective of this study was to determine both the influence and effect size of a number of factors (including gender, ageing period, endpoint temperature, cut type, cooking method as well as level of soyabean lecithin supplementation to finisher pigs), and their interactions, on consumer acceptability of pork to improve pork consistency and reducing the fail rate of pork to less than 5%. Three separate consumer sensory studies were conducted in this study.

The first study involved 60 (Large White x Landrace, PrimeGro™ Genetics) pigs of three sex groups (entire male, female and surgical castrates) with 20 pigs per sex. Three primal cuts (loin, silverside and shoulder) from both sides of the carcase and three cooking methods (roast and stir fry (all primals) and grilling as steaks (loin only)) were evaluated. Each cut was either aged for 2 or 7d post-slaughter and cooked to either a 70 or 75°C endpoint temperature. The objective of this study was to determine the influence and size of these factors, and their interactions, to improve pork consistency and reducing the fail rate of pork to less than 5%. The hypotheses being tested were that entire males will produce pork of poorer eating quality with higher fail rates than female and surgically castrated males; ageing for 7d post-slaughter, rather than 2d post-slaughter, will improve sensory scores for tenderness, juiciness and flavour; cooking to an endpoint temperature of 70°C, rather than 75°C, will minimize moisture loss and improve consumer scores, particularly for tenderness and juiciness of pork; eating quality will vary due to cooking method used for the loin, silverside and shoulder primals.

Overall liking of pork was influenced, in order of importance, by flavour, tenderness, juiciness and aroma. Juiciness, flavour, overall liking, quality grade and intramuscular fat content were influenced by sex of the pig, with lower scores obtained for pork from entire males than surgical castrates, with females intermediate. Fail rate, based on the percentage of consumer evaluations that scored either 1 (unacceptable) or 2 (below average) for quality grade was higher for pork from entire males than from females and surgical castrates. Fail rates for re-purchase intention based on scores of either 1 (I definitely would not buy it) or 2(I probably would not buy it) were also higher for pork from entire males than females and surgical castrates. Neither ageing period nor cooking temperature resulted in significant improvements in sensory quality. However, the effects of cooking were large, and significant, for all sensory variables assessed in this study. Across all seven cut x cooking method combinations, loin steaks and silverside roasts obtained the lowest scores for tenderness, juiciness, flavour, overall liking, quality grade and re-purchase intention. Overall, cuts obtained from the shoulder (blade and chuck tender) were more preferred than those from the loin and silverside. Fail rates were higher for the loin steak and silverside roasts than the other cut x cooking method treatments. Stir frying resulted in higher scores for aroma, overall liking, quality grade and re-purchase intention (for all cuts), and tenderness and juiciness (for blade and silverside only) compared to roasting. Fail rates of stir fried pork were lower than for roasts, for all three primals evaluated. Positive effects of cooking to an endpoint temperature of 70°C were found for stir fry for tenderness, juiciness and overall liking, whilst steaks cooked to 70°C were also juicier and obtained higher scores for flavour, overall liking, quality grade and re-purchase intention than those cooked to 75°C.

These results highlighted that for the development of a cuts-based eating quality system, there will be a need to incorporate a number of pathway interventions to result in delivery of different pork cuts with low fail rates, to allow for differences in cooking method used. It was demonstrated in this study that both ageing for 7 days and cooking to 70°C do not result in sizeable improvements in product consistency, especially at a cuts level when different cooking methods are used. It also demonstrated that eating quality assessments of one cut, such as the loin (which the majority of previous studies have assessed), cannot be reliably used to determine effects of pathway interventions on eating quality consistency of different cuts, when cooked using different methods.

Soyabean lecithin supplementation has previously been shown by Akit et al. (2011) to influence collagen content and solubility. This is supported by lower chewiness and cohesiveness values of pork, reduced hydroxyproline content as well as decreased procollagen gene expression and also expression of prolyl 4-hydroxylase, an enzyme involved in collagen biosynthesis through the hydroxylation of proline to hydroxyproline which results in the stabilisation of the collagen triple helix. The two latter studies tested the hypothesis that soyabean lecithin supplementation to finisher pigs would reduce the contribution of connective tissue to pork tenderness and result in improved consumer acceptability of pork compared to pork from pigs not supplemented with soy lecithin and that this effect would be similar for pork from entire males, females and immunocastrated males.

The second of these studies investigated the effect of supplementation of soy lecithin to female pigs at 5, 20 or 80 g/kg feed for 5 weeks prior to slaughter. No effect on eating quality was observed between dietary treatments. In addition, the fail rates of pork from this study were high, ranging from 25% (20 g/kg) to 40% (5 g/kg), despite loin steaks being cooked to an endpoint temperature of 70°C. The third study conducted in this project involved determining the effect of supplementation of 8 g/kg soy lecithin to entire male, immunocastrated male and female pigs for five weeks prior to slaughter. No significant improvements in pork eating quality were found compared to pigs that were not fed soy lecithin. However, the fail rates of loin steaks, for both quality grade and re-purchase intention, were higher in control animals that lecithin supplemented pigs. Furthermore, fail rates of steaks from female and immunocastrated male pigs were lower than those for entire males for both quality grade and re-purchase intention. The lower fail rate of pork steaks following supplementation of soy lecithin of female and immunocastrated males is of interest and may be worthy of further exploration. Based on these eating quality results alone, the inclusion of dietary lecithin in pig diets to improve pork eating quality consistency is not considered to be an appropriate intervention option for an eating quality pathway.

As a result of the outcomes in this study the following recommendations have been made:

- Given the higher fail rate of pork cuts from entire males compared to females and surgical castrates, together with lower scores for juiciness, flavour, overall liking as well as lower intramuscular fat content of loins and silverside muscles, it is recommended that entire males are not included as part of an eating quality system to deliver pork of guaranteed high eating quality to consumers.
- None of the quality interventions imposed in this study resulted in markedly large improvements in pork consistency, assessed from quality grade scores.
- Other than non-inclusion of pork from entire males and recommendations to cook pork loin steaks and stir fry pieces to a endpoint temperature of 70°C, it was not possible to provide clear recommendations on pathway parameters that enable low fail rates of <5% to be achieved.

- The positive effect of soyabean lecithin supplementation on collagen structure and synthesis was not discernable by consumers and is not suggested to be incorporated into the eating quality pathway for delivery of consistent quality pork.
- Further work is required to improve eating quality performance of loins and silversides, particularly when cooked as a steak or roast.
- The next phase of this work will focus on further development of eating quality system methodology, utilizing outcomes from other Pork CRC Program 3 projects, for the validation studies, to refine proposed eating quality pathways aimed at delivering consistent quality pork to consumers. This will involve working through potential pathway interventions for various product types to allow a system to be established to allow cooking methods to be specified for different cuts. For example, what will be needed for a female 85 kg HCW carcase to have cuts graded as ‘good everyday’ and what intervention steps would be needed for cuts to be graded as ‘platinum pork’.

Table of Contents

Acknowledgments i

Executive Summary ii

1 Introduction 1

2 Methodology 3

2.1 Effect of sex, ageing period, cut type, cooking method and endpoint temperature on eating quality of pork *3*

2.1.1 Animal management 3

2.1.2 Objective measurements 5

2.1.3 Sensory evaluation 6

2.1.4 Statistical analysis 14

2.2 Smaller Sensory Studies *17*

2.2.1 Consumer Recruitment 17

2.2.2 Allocation of Frozen Samples into Sensory Sessions 17

2.2.3 Sample Preparation 18

2.2.4 Cooking Protocol 18

2.2.5 Presentation Protocol 18

2.2.6 Consumer Evaluation 18

2.2.7 Study designs and statistical analysis 18

3 Outcomes **20**

3.1 Effect of sex, ageing period, muscle, cut type and endpoint temperature *20*

3.1.1 Objective measurements 20

3.1.2 Sensory results 25

3.2 Effect of lecithin treatment on sensory quality of loin steaks from female pigs *43*

3.3 Determining the effects of dietary lecithin and immunocastration on sensory quality of group-housed finishing pigs. *45*

4 Application of Research **50**

4.1 Effect of sex, ageing period, cut type, cooking method and endpoint temperature on eating quality of pork *50*

4.1.1 Sex 50

4.1.2 Ageing period 50

4.1.3 Cut type, cooking method and effect of endpoint temperature 51

4.2 Effect of lecithin treatment on meat quality, carcase quality and growth performance of female pigs. *55*

4.3 Determining the effects of dietary lecithin and immunocastration on growth performance and carcase characteristics of group-housed finishing pigs *55*

5 Conclusion **56**

6 Limitations/Risks **56**

7 Recommendations **57**

8 References **58**

1 Introduction

Tenderness, juiciness and flavour are the key eating quality attributes that influence consumer appreciation of pork, but there is no simple 'on-line', low cost tool available to industry to grade carcases for these traits. Previous research has determined and documented the importance of a number of pre- and post-slaughter management factors on the eating quality of pork, but this information has not been integrated into an eating quality system. Work to develop a non-prescriptive eating quality assurance system (proposed initially to have two levels – standard and graded/eating quality assured) commenced in 2009 by The University of Melbourne as part of an APL funded study (2009-2269). In contrast to the red meat industry where the Meat Standards Australia (MSA) grading system has been implemented to predict eating quality, the Australian pork industry has relatively underdeveloped systems for the systematic prediction of pork eating quality. Only a few studies (Channon *et al.*, 2001; D'Souza and Mullan, 2002; D'Souza *et al.*, 2003) have investigated the importance of pathway factors on the eating quality of pork. Importantly, the majority of the eating quality research conducted on pork has not been conducted with a pathway approach in mind, with few studies reporting interactions of factors from across the supply chain.

Channon et al., (2001), using an example of the additive effect of hanging method and ageing period, indicated that the lower and upper quartiles of the mean grade scores were increased when the interventions were put in place and these shifts were about the same as the shifts in the means. This suggested that the treatment interventions shift the location of the distribution of the mean, but not the variance, of the mean grade scores. It was concluded that it was 'not possible to recommend as strategy to ensure that industry produces 100% of pork with mean grade scores greater than 3 (average quality, may buy on some occasions)'. With further sensory work to obtain additional information, particularly quality grades and purchase intention, this will provide opportunity to quantify how quality can be shifted by implementation of particular pathway interventions. However, hanging method was not favourably viewed by processors due to changing muscle shape, additional space required in chillers for aitchbone hung carcases and additional labour required on the slaughter floor.

Work to date (Channon *et al.*, 2011a) has attempted to quantify the impact of key critical control points using a pathway approach that can influence eating quality attributes of fresh pork, with a view to implementing pathway interventions to improve the consistency of pork eating quality. An extensive database of previous research that reported effects on pork eating quality has been compiled. The majority of studies were obtained from peer-reviewed journals and several unpublished final reports from previous Australian pork quality research (Saunders *et al.*, 2000; Channon *et al.*, 2001). The analysis approach taken was to arbitrarily set parameters for a 'standard' Australian pig and use both linear and non-linear regression analysis of single-order relationships comparing different variables within each parameter with that for the 'standard' pig for sensory tenderness, flavour and juiciness. Linear regression models implied that gender, genotype class, halothane gene, nutritional management and the use of metabolic modifiers, ageing period, moisture infusion, internal temperature, cooking method and muscle influenced eating quality attributes when compared with the variables set for the 'standard' pig. Overall, the effects of production factors were shown to be of lesser importance compared with post-slaughter effects on sensory scores.

The work conducted to date has its limitations in that only the effect of singular factors on eating quality could be quantified due to the nature of the data available and analysis methods used. However, it was very useful in identifying key critical control points, knowledge gaps and framing further work required in the development of an eating quality system for Australian pork. It was highlighted that more data to better quantify the relationship between immunocastrated males and females is needed. In addition, knowledge of interactions between production factors eg. gender x metabolic modifiers x plane of nutrition and diet composition for Australian genotypes is lacking. For example, Moore et al. (2012) showed that feeding ractopamine at 5 ppm for 28 days or 5 ppm for 14 days followed by 10 ppm for a further 12 days significantly improved feed conversion ratio of both entire and immunocastrated male pigs, however effects on eating quality following ractopamine administration to immunocastrated pigs has not been reported. There is also little existing information on different muscles other than the loin or extensive studies that compared different cooking methods and final endpoint temperatures on sensory attributes of pork. This project is linked with other Pork CRC projects investigating the effect of nutritional level, protein content of the diet and investigations of the effect of ultimate pH and packaging on pork eating quality. Information arising from these projects will be sought to include into the eating quality database and to update the predictive model.

Soya bean lecithin was investigated in Pork CRC project 3A-109 as a dietary means of improving meat tenderness. Akit et al., (2010) investigated whether dietary supplementation of soya bean lecithin to pigs (at either 4, 20 or 80 mg/kg) can decrease the development of intramuscular connective tissue and result in more tender pork with increased intramuscular fat content without changing backfat levels. Although lecithin treatment did not influence shear force, collagen stability appears to have been affected, with lower hydroxyproline levels found in pork from lecithin-fed pigs as well as lower chewiness and cohesiveness values compared to control pigs. As a dietary ingredient, the addition of soy lecithin could be readily uptaken by industry to reduce the contribution of collagen to pork toughness. Consumer evaluation of pork is being undertaken in this project to determine if the effects of soy lecithin on connective tissue results in eating quality improvements.

It is recognised that any system developed must take a conservative approach, such as that of Meat Standards Australia, to ensure that consumer expectations for eating quality assured pork are consistently met. The sizeable impact in sensory quality between muscles, cooking method used and endpoint temperature indicates that further work is required to better understand the size of potential interactions between muscle, cut type, cooking method used and final endpoint temperature. This will enable knowledge to be broadened rather than restricting it to grilled loin steaks. This work, particularly including quality grades, re-purchase intention and willingness to pay, will provide opportunity to quantify the extent to which quality can be shifted by implementation of particular pathway interventions

2 Methodology

The study was originally designed using 80 pigs of four sex groups (entire male, female, surgical castrates and vaccinated castrates) with 20 pigs per sex. Three primal cuts were evaluated (loin, silverside and shoulder) and three cooking methods (roast, stir fry (all primals) and grilling as steaks (loin only)). Each cut was either aged for 2 or 7 days (d) post-slaughter and cooked to either a 70 or 75°C endpoint temperature. The objective of this study was to determine the influence and size of these factors, and their interactions, to improve pork consistency and reduce the fail rate of pork to less than 10%. This information would then be incorporated into an eating quality model to enable consistent delivery of high quality pork to consumers and be used to provide recommendations to the Australian pork industry on effective pathway interventions that may be implemented. The hypotheses being tested were that entire males produce pork of lower eating quality to consumers; ageing for 7d post-slaughter, rather than 2d post-slaughter, will improve sensory scores for tenderness, juiciness and flavour; cooking to an endpoint temperature of 70°C, rather than 75°C, will minimize moisture loss and improve consumer scores, particularly for tenderness and juiciness of pork; and eating quality of different cuts will vary with cooking method used.

2.1 Effect of sex, ageing period, cut type, cooking method and endpoint temperature on eating quality of pork

2.1.1 Animal management

A total of 80 pigs (Large White x Landrace, PrimeGro™ Genetics) were sourced for this study from a piggery located in Northern Victoria. At birth in June 2011, piglets were randomly allocated to gender treatment (n=20 per gender) – females; entire males; surgical castrates or immunocastrates. Males allocated to the surgical castrate treatment were castrated at 1 day of age and all pigs were injected with iron at birth. Animals allocated to the immunocastration treatment were vaccinated with Improvac at 10 weeks of age and were scheduled to receive their second vaccination at 15 weeks of age. Animals were slaughtered over two slaughter days at 21-22 weeks of age, one week apart, in November 2011. Liveweight was obtained for all pigs in this study at birth, at the commencement of the finisher phase and on the day prior to slaughter. Animals were individually tattooed on the day prior to slaughter to allow for identification of individual carcases on the slaughter floor.

Diet specifications fed to pigs in the finisher phase are shown in Table 1. Pigs in this study were not fed ractopamine in the finisher diet or treated with pST.

Table 1: Specifications of diets fed to pigs during the weaner, grower and finisher phases in this study

	Diet specifications		
	Weaner (5-15 kg liveweight)	Grower (15-60 kg liveweight)	Finisher (60-100 kg liveweight)
Protein (%)	22.53	16.15	13.01
DE/MJ kg	14.46	14.00	13.79
Fat (%)	3.08	2.91	2.96
Fibre (%)	2.45	3.22	4.03
Lysine (%)	1.42	0.92	0.78

All animals were minimally handled both on farm and at the abattoir and remained in their separate sex x slaughter date groups for the entire finisher period, during transport and in lairage. Pigs were transported 300 km for a duration of 3 hours to the abattoir, unloaded and held in lairage for 17 hours prior to slaughter, with access to water, at a commercial abattoir located in southern New South Wales, Australia. Each gender group was moved separately to the point of stunning with minimal handling and stunned using 90% carbon dioxide (Butina, Denmark). Following evisceration, a fat sample was obtained from each carcase from the belly, individually labeled and frozen at -20°C until required for analysis.

Hot carcase weight (AUS-MEAT Trim 1) and fat depth at the P2 site, using PorkScan (PorkScan Pty Ltd, Canberra, Australia) was measured and recorded for all carcases and carcases were split prior to chilling. On both slaughter days, carcases were placed in the same chiller, fitted with overhead fans, and conventionally chilled according to standard commercial practice (1-2°C for 24 hours). Measurements of muscle pH and temperature decline post-slaughter were made in the *M. longissimus thoracis et lumborum* (loin) adjacent to the P2 site at 45 min, 90 min, 3 h and 6 h post-slaughter in both sides of each carcase using a portable pH meter fitted with a polypropylene spear-type gel electrode and a separate temperature probe.

At 24 h post-slaughter, cold carcase weight was obtained and carcases were boned. Boneless loin, silverside (*M. biceps femoris*) and shoulders were collected from both sides of each carcase. These primals were then prepared into the required cuts for both sensory and technological quality assessment. For the loin, a 2-3 cm slice was removed from the caudal end and a total of four 2.5 cm thick steaks were then sliced, de-rinded and denuded of subcutaneous fat, labeled and individually vacuum packaged. A 15 cm piece, for roasting, followed by a 10 cm piece for preparation into stir fry samples were then cut, labeled and individually packaged. The remaining piece was used for objective meat quality measurements. For the silverside, a 10 cm roasting piece was firstly cut, followed by another 10 cm piece for stir fry with the remaining muscle used for objective meat quality measurements. The bolar blade (*M. triceps brachii*), for roasting, and chuck tender (*M. supraspinatus*), for stir fry, were removed from the pork shoulder. Two different muscles were used from the shoulder as the bolar blade cut was not large enough to supply meat for both cooking methods and the chuck tender was selected as it was preferred in order to ensure that consumers evaluated the same muscle. All roasting pieces retained rind and subcutaneous fat which was removed by the chef after cooking prior to being assessed by the consumer panel. Within each slaughter day, two carcases per sex were blocked into one pair. Ageing period (2 or 7 days) and endpoint temperature (70 or 75°C) was then randomly allocated to a side within each pair. The four treatment combinations were then allocated to the four sides. The individual samples were labelled during preparation at Rivalea with a 4 digit random number along with details of carcase side and number, type of primal, gender, ageing period and degree of doneness allocation. Cuts were boxed and frozen at either 2 or 7 days post-slaughter, depending on treatment allocation. Pork was then transported by truck in a freezer to Adelaide, where it was held at -18°C until required for sensory assessment.

In summary, the primal cuts used were loin, shoulder and silverside; these were vacuum packaged and aged for two and seven days post-slaughter before freezing. The cooking methods employed for the sensory assessment were grilling (boneless denuded loin steak only), stir frying (loin, shoulder (chuck tender) and silverside) and roasting (loin, shoulder (bolar blade) and silverside) and were cooked to either medium (70°C) or medium/well done (75°C).

2.1.2 Objective measurements

2.1.2.1 Androstenone and skatole

Belly fat samples were analysed for androstenone (surgical castrates, immunocastrates and entire males) and skatole (all genders) by Frontage Laboratories Co., Ltd. (Shanghai, China). The concentration of androstenone was conducted using high performance liquid chromatography with mass spectrometric detection (HPLC/MS/MS). Skatole was determined using high performance liquid chromatography – fluorescence detection (HPLC-FLD). The results of assays conducted to determine androstenone and skatole levels in immunocastrated males indicated that either these pigs did not receive their second Improvac injection at 16 weeks of age or that it was not effective (Table 2). Pork from the 20 immunocastrated pigs were therefore removed from this study and the study design revised to only include entire males, females and surgical castrates.

This reduced the total treatments to 84; total pigs to 60; total carcase sides to 120; total primal cuts to 840; and total evaluations to 3360. With seven pork samples evaluated by each consumer in a single session a total of 480 consumers were now required for the study.

Table 2: Androstenone and skatole concentrations in fat from female, surgical castrate, immunocastrate and entire male pigs

Gender	Androstenone (ng/g)	Skatole (ng/g)
Female	n.d.	45
Surgical castrate	108	38
Immunocastrate	693	226
Entire male	753	185
s.e.d.	134.8	43.9
P value	<0.001	<0.001

2.1.2.2 Objective assessments

Muscle pH and temperature and meat colour was determined after ageing for either 2 or 7 d post-slaughter. Muscle samples from all muscles were exposed to air at room temperature for 10 min. Meat colour was determined using a Minolta Chromameter Model CR-400 (calibrated on a white tile) set on the L*, a* and b* system where L* denotes relative lightness (higher L* values = paler meat), a* relative redness (higher a* values = more red) and b* relative yellowness (higher b* values = more yellow), using D65 illumination and a 2° standard observer.

After ageing, the loin and silverside sample was prepared into one 70±5 g block for Warner-Bratzler shear force (WBSF) assessment, a 20 g block for drip loss assessment and remaining trim reserved for analysis of intramuscular fat content. WBSF and drip loss were not determined for the shoulder due to lack of sample. Samples for WBSF assessment and intramuscular fat were then labelled, individually bagged and frozen at -20°C. Samples for WBSF were cooked from frozen state and dependent on internal temperature treatment, cooked in a waterbath preheated to either 70 or 75°C until an internal temperature of 70 or 75°C was attained. Each sample was suspended from a metal rack and cooked in a water bath. Samples were then cooled in iced water for 30 minutes. Samples were dried and weighed to determine cooking loss (expressed as a percentage of weight lost due to cooking) and then stored at 4°C for 24 hours. From each sample, five 1 cm^2 replicate samples were cut parallel to the orientation of muscle fibres and WBSF was measured using a Warner Bratzler shear blade fitted to a Mecmesin BFG500N (Bodine Electric Company, Chicago, USA).

Muscle samples for measurement of intramuscular fat were sent for analysis to George Weston Foods, Enfield, New South Wales using Soxhlet extraction (AOAC Method 920.39, 17th Edition, 2000).

Drip loss was determined using a modified method of Rasmussen and Andersson (1995). A sample of pork loin was cut to a 20 g cube, weighed and weight recorded. The sample was then wrapped in 20 cm^2 piece of square netting. The wrapped sample was then suspended in a 200ml plastic container and left to stand in a 4°C chiller for 24 h, after which it was removed from the container, gently rolled in paper towelling and reweighed to determine percentage drip loss.

2.1.3 Sensory evaluation

The consumer panel was designed to determine sensory attributes of aroma, tenderness, juiciness, flavour and overall liking for each pork sample assessed. Demographic information (gender, household size, age, current purchasing, cooking and consumption habits of fresh pork) was captured for each consumer along with a quality grade and re-purchase intention score for each pork sample evaluated.

The preparation and cooking protocols for the sensory evaluation of pork samples in this study were previously determined as part of an Australian Pork Limited (APL) funded project (2009-2269). However, cooking protocols were updated because different models of equipment (Smeg oven and Silex grill) were used in this study. These are detailed in the preparation and cooking sections for roasting and grilling below. The consumer sensory sessions were conducted at one central location at the University of South Australia (UniSA) sensory facilities based at the city centre campus in Adelaide. Two smaller sensory studies were also conducted in this project at the SARDI Waite campus in Urrbrae, South Australia.

2.1.3.1 Consumer Recruitment

Consumers were recruited by an independent recruitment company (Intuito Market Research). The early process for recruitment included emailing their extensive database of consumers willing to participate in taste testing as well as running advertisements in local Adelaide newspapers (The Advertiser and Sunday Mail).

The specifications for recruitment were that all participants needed to be consumers who had eaten fresh pork (not bacon or ham) in the past month and who were aged between 18 and 65 years. Butchers and other people working with meat production and sales were excluded. Individuals (n=480) were asked to join a panel of eight consumers for approximately one hour at varying times of the day from 10.00 am to 3.00 pm or 2.00 pm to 7.00 pm with three sessions per day on three pre-determined days per week from Monday to Saturday.

Potential participants registered with Intuito either online or over the telephone and were contacted by a recruiter to arrange a time that would suit them to attend. Participants who cancelled their appointments were replaced using the database generated of over 1,000 consumers. Participants were given an honorarium for their participation in the study and were used only once.

2.1.3.2 Allocation of Frozen Samples into Sensory Sessions

The pork samples, prepared and frozen at Rivalea (Australia) Pty Ltd were transported to the butchery department at the Technical and Further Education (TAFE) Regency campus in Adelaide and arrived on 10 April 2012. The cartons containing the samples were stored in a holding freezer at -18°C for two days after which time the samples were removed from the cartons and sorted into their pre-allocated sensory sessions.

The sorting was undertaken in a controlled temperature room (12°C) in the TAFE butchery department. For each sensory session, a total of 20 pieces per session (10 per side) were required:

a) 8 loin steaks
b) 2 loin roasts
c) 2 silverside roasts
d) 2 bolar blade roasts
e) 2 loin stir fry
f) 2 silverside stir fry
g) 2 chuck tender stir fry

Duplicate copies of a one page session labelling document were prepared in advance for every session to indicate which samples (n=20) were required for the sessions. The document showed the session number, gender, final endpoint temperature, carcase number and a list of the 4 digit codes for each sample required for the different cooking methods. Outer labels were also prepared for the labelling of cartons for each session; these included session number, gender, final endpoint temperature and carcase number.

The following method was used to prepare the samples for each session (completed by three people in one day).

- Samples were removed from the cartons and laid out on tables in order of carcase number, from 1 to 60.
- The 20 samples required were located using one copy of the session labelling document, checked off the list and put inside a plastic liner into a carton in a single layer. A separate carton was used for each session and each person was responsible for one sensory session at a time, from 1 to 60.
- Once all 20 samples had been located, the plastic liner was folded over the samples. The duplicate copy of the labelling document was placed on top, the carton sealed, labelled with three outer identification labels and placed onto a pallet in the holding freezer at –18°C. The checked labelling documents were retained.

This process continued until all 60 sessions were completed and placed back into the holding freezer. The cartons (n=60) were retained by TAFE for five days after which time the cartons were transported to the SARDI Waite campus by commercially refrigerated transport on 18 April 2012. On receipt, the cartons were immediately placed into a -18°C storage freezer and sorted into numerical order of sessions with Session 60 being placed on the bottom of the pallet and Session 1 at the top.

2.1.3.3 Thawing and preparation protocols

A thawing protocol was developed for samples required per testing day (three sensory sessions per day) to ensure samples of varying sizes/dimensions would be defrosted to the same temperature prior to being prepared and cooked. This protocol also determined the thawing schedule based on the dates of the sessions to ensure all samples undertook the same thawing time prior to use. Samples were thawed in their sealed cartons of individual sensory sessions to ensure no confusion or mix up of samples when multiple sessions were required to be thawed at the same time.

Samples from immunocastrated males were used in a trial to determine a thawing protocol. A hole was drilled into the centre of a -18°C loin roast (as this primal cut had the largest mass) and a temperature data logger with remote probe sensor inserted. The carton was filled with a representative sample of the other 19 pieces required to complete a session (in a single layer) and placed into a constant temperature room of 4°C. The temperature was recorded at 30 minute intervals for 113 hours. After 48 hours the temperature had reached -1.6°C. At the end of the recorded period the internal temperature of the loin roast piece had thawed to 2.9°C.

The thawing protocol developed was to remove the cartons (n=3) required for one day of sensory sessions from the -18°C freezer at 8 am or 12 pm (depending on the sensory sessions times for that day) and place them into the 4°C constant temperature room for between 44 and 52 hours. This protocol was also beneficial because as samples were collected from the 4°C room to transport to the testing location, other samples could be removed from -18°C for thawing. Samples were prepared for the sensory sessions between one and seven hours after removal from the 4°C room.

On each day of the sensory sessions the three cartons of samples required were collected from SARDI Waite campus (at either 8 am or 12 pm) and transported to the central testing location at UniSA by car. The cartons were transported in the boot of a car and the journey was approximately 15 minutes. The majority of the sensory sessions were undertaken during June (from 6 June 2012 – 9 July 2012). The average minimum temperature in June was 7.9°C (Australian Government, Accessed 4 Sept 2012). The samples were not transported under refrigerated conditions due to the short transport time and low ambient temperature.

On arrival at the test location, the samples were removed from the carton. Samples for Sessions 2 and 3 were placed on separate shelves in a domestic fridge (5°C) and preparation commenced with samples for Session 1.

On removal from the carton, the 20 individual samples were checked against the session labelling document to ensure the session contained the correct samples. The 4 digit number was used as the primary identification tool. Each sample was identified by its unique 4 digit number and this ID followed the sample from removal from its vacuum packaging to presentation to the sensory panellist for evaluation.

The preparation method undertaken for each of the primal cuts prior to cooking is described below.

<u>Roast</u>
This cooking method was undertaken on all primal cuts (loin, shoulder: bolar blade and silverside) with six samples roasted in each session, two of each type. The roast pieces were removed from vacuum packaging and labelled with their 4 digit number. A portion was removed from the loin roasts and some of the silverside roasts to cut them to a similar weight and size as the bolar blade pieces. Three roast pieces were placed onto a greaseproof paper lined roasting tray (with removable drip tray) and an oven proof label attached to the tray to identify each piece. Two trays of roasts were required for each session.

A meat thermometer (a stainless steel probe with a 1m lead connected to a digital thermometer on the outside of the oven) was inserted into the centre of each roast and used to monitor the internal temperature of the roast pieces throughout cooking. Each thermometer was also labelled with the matching 4 digit number for the roast. The thermometer alarm preset function was used to set temperatures depending on the final endpoint temperature required for the session. The temperature of the roasts was 1-3°C before cooking commenced.

Grill

This cooking method was undertaken on loin steaks only, with eight steaks in each session. The steaks were removed from the vacuum packaging and labelled with their 4 digit number. They were measured for length, graded into large and small sizes, placed onto a tray and stored at 5°C until required.

The steaks were sorted into small and large sizes based on revised grilling protocols developed from trials with the Silex grill purchased for this study. The grilling trials undertaken are described in further detail in the grilling cooking protocols section below and resulted in different grilling times for different steak sizes, hence the requirement for the loin steaks to be graded prior to being cooked. The temperature of the loin steaks was 5-7°C before cooking commenced.

Stir Fry

This cooking method was undertaken on all primal cuts (loin, shoulder: chuck tender and silverside) with six samples to be stir fried in each session, two of each type. The stir fry primal cuts were removed from vacuum packaging and labelled with their 4 digit numbers. Pieces for stir frying were cut to 50 mm x 10 mm x 10 mm, each weighing about 7 g. Approximately 15 pieces were dissected from each primal cut (12 pieces were required for each session). The 15 pieces were placed into a plastic storage container, labelled on the outside with the 4 digit number and placed in the fridge at 5°C until required. The temperature of the stir fry pieces was 5-7°C before cooking commenced.

2.1.3.4 Cooking Protocols

The different cooking methods undertaken for each of the primal cuts before consumer evaluation are described. The seven samples to be evaluated by each consumer were in a randomised tasting order so the cooking of samples (n=20) could not be done to order.

Roast

The oven utilised at the UniSA facilities was a Smeg electric single oven Model SA20XMFR 90 cm (Smeg, 2 Baker Street, Banksmeadow, NSW, Australia). At the start of each day the oven was set to fan forced mode and pre-heated to the required temperature. This oven was a different model to the one that had previously been used in APL Project 2009-2269. Oven trials were completed at a test day at UniSA prior to the start of the study to determine the optimum oven heat and thermometer settings to produce pork roasts cooked to the required final endpoint temperatures for the study (70°C and 75°C) after a five minute resting period. Pork from immunocastrated males were used for this trial.

As previously reported in APL Project 2009-2269, the roast cooking times were variable (approximately 10 minutes) even with relatively consistent dimensions and weights and regardless of location in the oven. The results of this trial indicated a fan forced oven setting of 175°C and thermometer settings of 69°C and 75°C (to signal removal of roasts from the oven) would achieve a medium ‘degree of doneness’ (70°C) and medium/well done ‘degree of doneness’ (75°C) respectively after a five minute resting period.

The two trays of six roasts were placed on separate shelves in the pre-heated oven approximately 75 minutes before the start of each sensory session. The temperatures of the roasts were monitored throughout the cooking period. Once a roast had reached the required temperature (69°C or 75°C) and the thermometer alarm sounded, the roast and its ID label were removed and placed on a wire rack located on the bench above the oven for the resting period. At the start of each day, the roasts were monitored for temperature during the resting period to ensure the equipment was functioning as expected. After this confirmation, further resting period temperatures were not monitored.

Grill

The grill used for this study was a Silex Grill Model GTTPowersave 10.10-30 (Silex Elektrogerate GmbH, 22143 Hamburg, Germany). This grill was also different to that used in APL Project 2009-2269. Before the study commenced, trials were undertaken to determine the optimum heat setting and grilling time for the loin steaks to produce grilled steaks cooked to the required final endpoint temperature for the study (70°C and 75°C) after a two minute resting period. Pork steaks from immunocastrated males were used for these trials.

In the sample preparation at Rivalea, four steaks were cut from the loin primal from one carcase side and their relative position on the loin (1-4) recorded so this information could be reviewed at a later stage if required. A decision was taken to grill two steaks at one time to ensure there would be no confusion or mix up of the loin steak IDs during the grilling and serving procedures.

For the test trials, two steaks were grilled at a time and the temperature of each steak monitored through the grilling and resting periods with a k-type thermocouple attached to a digital thermometer. It was noted that there was variability in the size (length) of loin steaks which affected the ability to have a single grilling time for all steaks to achieve consistent degrees of doneness. These trials resulted in a new cooking protocol (Table 2) for grilled loin steaks in this study.

The loin steaks were measured in length and graded into small (≤130 mm) and large (>130 mm) sizes which resulted in different grilling times for each size to deliver the required final endpoint temperature (Table 3). A grill temperature of 160°C was determined to be the optimum heat setting. This temperature produced a more consistent temperature rise during the resting period than higher or lower temperature settings.

Table 3: Grilling protocol for different sizes of pork loin steaks for two degrees of doneness (70°C and 75°C)

Loin Steak Size	Required Degree of Doneness (after 2 mins resting)	Grilling Time at 160°C
Small (≤130mm length)	70°C	3 minutes, 10 seconds
Small (≤130mm length)	75°C	3 minutes, 40 seconds
Large (>130mm length)	70°C	3 minutes, 25 seconds
Large (>130mm length)	75°C	3 minutes, 55 seconds

Approximately 30 minutes before the start of the sensory session, the grill was pre-heated to 160°C and cooking commenced. The loin steaks were brushed on each side with rice bran oil before being placed onto the grill plate and the lid lowered. To maintain sample identification once the steaks were placed on the grill, their corresponding labels were secured on either side of the grill stand. Duplicate labels were also placed on the cutting board next to the grill.

At the start of each session, the internal take-off and resting temperatures were measured for the first two steaks cooked to ensure the equipment was functioning as expected. After this confirmation, the loin steaks were cooked to the required time and no further product temperatures monitored. The grilling and resting times were measured with digital timers.

Once the steaks had been grilled for the required amount of time, they were removed from the grill and placed next to their ID label on the cutting board for resting. This process was repeated until all eight steaks had been cooked for the session. In between each sensory session the grill was switched off and the plates thoroughly cleaned with hot water and detergent.

Stir Fry

The two woks used in this study were Sunbeam electric woks Model WW4500D (Sunbeam, Locked Bag 5041, Botany, NSW, Aus). Approximately 30 minutes before the start of the sensory session both woks were pre-heated to setting Number 7. A tablespoon (approximately 5 g) of rice bran oil was added to Wok 1 and pre-heated for 30 seconds before one batch (15 pieces) of stir fry was cooked, turned every 15-20 seconds for even colour development during cooking. Due to the short resting time after stir frying to achieve the required final endpoint temperature (results reported from APL Project 2009-2269), all batches of stir fry were continuously monitored for temperature throughout the cooking and resting periods; with a k-type thermocouple attached to a digital thermometer.

Once the first batch of stir fry was cooked to the required final endpoint temperature it was removed from the wok and placed into a labelled Pyrex holding container. Oil was added to Wok 2, pre-heated and the next batch of stir fry pieces cooked whilst the first wok was wiped out with a paper towel and prepared for the next batch of stir fry pieces. This procedure continued until the six stir fry batches had been completed for the session. In between the sensory sessions, the woks were switched off and thoroughly cleaned with hot water and detergent.

The grilling and stir frying was undertaken by two people in parallel to minimise the holding time of samples prior to consumer evaluation.

2.1.3.5 Presentation Protocols

The kitchen/preparation room was maintained at a temperature of 23°C during the sensory sessions. In each session, the samples (n=7) evaluated by each consumer (n=8) were in a randomised tasting order so the samples (n=56) needed to be prepared and ready to serve for the start of the sample evaluation section of the sensory session; approximately 10 minutes after the start of the session. The samples could not be prepared to order. Some samples were stored in the containers for up to 35 minutes prior to consumer evaluation.

To keep the prepared samples warm during the evaluation and prevent moisture loss they were stored in sealed and labelled glass Pyrex containers (World Kitchen, Rosemont, Illinois, USA) on top of heated warming plates (n=4) from Cuisinart Model CWT-240A (Cuisinart Australia, 24, Salisbury Road, Asquith, NSW, Aus). At the start of the day, the warming plates were preheated to the 65°C setting and the Pyrex containers (n=20) placed on top. A duplicate set of Pyrex containers was available so these could be placed on the warming trays to pre-heat for the next sensory session whilst the soiled ones were cleaned.

Roast

The roast pieces were prepared once the stir fried samples had been cooked and each roast piece (n=6) was prepared in the same way. The roast and its ID label were transferred from the bench above the oven to a cutting board and the temperature probe

removed after an identification check between the label on the roasting tray and digital thermometer.
The roast pieces were prepared as follows:

1) the rind and all visible fat were removed;
2) the piece was cut in half along the grain of the meat;
3) the cut flat surface was turned down onto the cutting board surface;
4) both half pieces were cut into 6 mm ±1 mm thick slices across the grain; and
5) all slices were placed into a Pyrex holding container and labeled.

A total of 18–24 slices were obtained from each roast piece with 12 slices required for each sensory session.

Grill
After two minutes resting on the cutting board, two steaks (grilled at the same time) were trimmed on all four sides to remove fat and edges and the centre piece used for consumer evaluation. This was transferred with its label to a Pyrex holding container. One steak piece was placed in an individual container. This process was repeated for the eight steaks required for each sensory session.

Stir Fry
The stir fry batch removed from the wok into the labeled Pyrex container was immediately transferred to the warming plate and sealed. This process was repeated for the six batches of stir fry required for each sensory session.

2.1.3.6 Serving of Samples to Consumers

A one page serving order document was prepared for all 480 consumers in the study. This document contained the order in which the seven samples were to be tasted (identified by order, sample description and 4 digit identification number) by each panelist in each session. Before the start of each session, the page corresponding to the correct session and panelist was secured above the booth for each consumer in the kitchen/preparation room. The seven sample plates were also pre-labeled with the 4 digit sample numbers and stacked in the correct tasting order by the booth.

The consumers were instructed to switch on a light once they were ready to evaluate a sample of pork. This action illuminated a duplicate light in the kitchen/preparation room which served as a signal to commence the serving process to that consumer. Two people undertook the serving of samples in a sensory session; one person responsible for serving Panelists 1-4 and the other for Panelists 5-8.

When a consumer was ready for a sample and the light was illuminated, the server would identify the panelist and sample number required. They would:

1) switch off the light to indicate the sample was being prepared;
2) collect pre-labeled sample plate from beside the tasting booth
3) locate the correct sample in the Pyrex container;
4) undertake a number identification check between plate and Pyrex container;
5) place sample onto the plate;
6) open the serving hatch and present the sample to the consumer; and
7) cross out the sample ID number on the serving order document.

This process was repeated for all seven samples and the protocol followed for all sensory sessions. The serving operation was completed in approximately 30 to 35 minutes per session.

The serving sizes for each cooking method were:

1) Roast: three slices
2) Grill: steak centre piece
3) Stir Fry: three pieces.

2.1.3.7 Consumer Evaluation

In each sensory session (n=60), eight consumers evaluated seven pork samples (56 tastings) with each primal cut per treatment (n=7) being assessed by four consumers in a session. The eight consumers registered at the start of each session were given a short briefing on the sensory evaluation process and then taken to the sensory evaluation room and placed in the eight individual tasting booths to start the session.

Panelists recorded assessments by touch screen through the use of a computerised sensory evaluation program, Compusense Five version 5.2 (6/9 Southgate Drive, Guelph, Ontario, Canada).

The session commenced with consumers answering a number of questions to capture individual demographic information which included: gender, household size, age, current purchasing, cooking and consumption habits of fresh pork. Consumers were then presented with each pork sample for evaluation on a numbered plastic plate as per the serving protocol described above. They were first asked to enter the 4 digit identification number for the sample, smell it and rate the sample for aroma. They were then asked to eat most of the sample before scoring for tenderness, juiciness, flavour and overall liking.

Consumers assessed the eating quality attributes of the pork samples using a continuous line scale as per Australian Standard for Sensory Analysis (2007). This method provided panelists with an opportunity to express small differences in judgment as they marked the line in the position corresponding to perceived intensity for that attribute. Although potentially a more difficult task for the consumer than using a category scale, the line scale permits unlimited fineness of differentiation among consumer assessments. To ensure that the scale was easily understood by panelists, the word anchors were carefully selected for each attribute and prior to the evaluation of pork samples, consumers completed a number of line scale practice assessments.

The continuous line scales used for the five quality attributes were anchored at each end with words with right hand side equivalent to 100 and left hand side equivalent to 0. Numerical intensity values were not shown to the consumers:

1) Aroma liking: Dislike extremely to Like extremely.
2) Tenderness: Not tender to Very tender
3) Juiciness: Not juicy to Very juicy
4) Flavour liking: Dislike extremely to Like extremely
5) Overall liking: Dislike extremely to Like extremely

Each consumer also graded the samples for quality into one of the following categories:

1) Unsatisfactory (this was terrible, I did not enjoy it all)
2) Below average (this was not nice, I did not enjoy it)
3) Average (this pork was nice, I somewhat enjoyed it)
4) Above average (this pork was really nice, I enjoyed it)
5) Excellent (this pork was excellent, I really enjoyed it)

Each sample was also rated for repurchase intention into one of the following categories:

1) I definitely would not buy it
2) I would probably not buy it
3) I might buy it

4) I would probably buy it
5) I would definitely buy it

Consumer assessment progress was monitored remotely on the laptop running the computerised program and assistance was provided when required. Consumers could not move onto the next question or assessment until the previous answer or assessment was completed. The session was completed once all consumers had assessed and rated their seven samples.

2.1.4 Statistical analysis

2.1.4.1 Animal performance and objective meat quality analysis

An analysis of variance was conducted using Genstat 13.1 (VSN International, 2010) to determine the effect of sex on growth performance and carcase attributes and the effect of sex, ageing period and endpoint temperature and their interactions on objective meat quality attributes. A blocking structure of day of slaughter was used in the ANOVA for growth performance, carcase measurements and meat quality measures of muscle pH, meat colour, drip loss and intramuscular fat. The analysis of variance for Warner-Bratzler shear force and cooking loss included a blocking structure of block within day to account for the allocation of sides to the ageing period x endpoint temperature treatments.

2.1.4.2 Sensory analysis

An analysis of variance was conducted to determine the effect of treatment factors and their interactions on sensory attributes of pork using R (R version 2.14.0, http://www.r-project.org).

There were four treatment factors: gender (3 levels), ageing period (2 levels), endpoint temperature (2 levels) and cut x cooking method (7 levels), making a total of 84 combinations. The study could therefore be considered to be a 3x2x2x7 factorial design. For the sensory analysis, two pigs per gender treatment were divided into two pairs. Each pair provided four sides allocated to one of four combinations of ageing (2 or 7 d post-slaughter) and internal temperature (70 or 75C) in one of three different ways. As there were 10 pairs for each sex, these three treatment allocations to carcase pairs could not be done equally often, and in each case two of them were done four times and the other done twice. Each case can be thought of as providing 3 degrees of freedom. The allocation of pigs and sides within pigs to a session is shown is Table 4.

With 60 pigs, 2 sides and 7 packs per side, there were a total of 840 Packs. For the consumer evaluation study, each pack was further subdivided into 4 samples for tasting, so that there were a total of 840 x 4=3360 samples to be tasted. Each consumer tasted 7 samples in a session, so 480 consumers (3360 samples/7 assessments =480 consumers) were required. There were 60 Sessions each involving 8 consumers.

Table 4: Allocation of pigs and sides within pigs to ageing and final endpoint temperature treatment

Case		i		ii		iii	
	Pig	1	2	1	2	1	2
Side	1	2d, 70°C	7d, 70°C	2d, 70°C	7d, 70°C	2d, 70°C	2d, 75°C
	2	7d, 75°C	2d, 75°C	2d, 75°C	7d, 75°C	7d, 70°C	7d, 75°C

The seven packs consisted of different cuts of meat to which different cooking methods were applied (Table 5):

Table 5: Cuts and cooking methods evaluated in this study

Sample	1	2	3	4	5	6	7
Cut	Shoulder (blade)	Shoulder (chuck tender)	Loin	Loin	Loin	Silverside	Silverside
Cooking method	Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry

For each cut obtained from each side of the carcase, four samples were obtained, providing 28 samples per side. Two sides provided the 56 samples required for each session. Table 6 details the design used to allocate samples to consumers within a session, with the letters A and B denoting the two sides used.

Table 6: Allocation of samples to consumers within a tasting session

Sample	Consumer							
	1	2	3	4	5	6	7	8
Shoulder Stir fry	1A	1B	1A	1B	1A	1B	1A	1B
Silverside Roast	2A	2B	2A	2B	2B	2A	2B	2A
Silverside Stir fry	3A	3B	3A	3A	3A	3B	3B	3A
Shoulder Roast	4A	4B	4A	4A	4B	4A	4A	4B
Loin Stir fry	5A	5A	5B	5B	5A	5A	5B	5B
Loin Steak	6A	6A	6B	6B	6B	6B	6A	6A
Loin Roast	7A	7A	7A	7A	7B	7B	7B	7B

Within a session, the two sides had the same endpoint temperature to minimize potential risks of error and thus had different levels of ageing period. Thus, in Table 4, cases (i) and (ii) involved taking sides from two different pigs, where case (iii) required two sides from the same pig. Each consumer saw all seven cooking methods, but either (i) saw all seven samples of the same ageing period if consumer 1, or (ii) saw three from one ageing period and four from the other ageing period if consumer 2-8. Ageing period and (cut x cooking method) was therefore partially confounded with consumers. As consumers are presented with their seven samples in order, it was imperative that they were not all given the cut x cooking method samples in the same order. A Latin Square was used to ensure each of the cut x cooking method combinations occurred once at each order. As there were eight consumers and seven cut x cooking methods in each session, one cut x cooking method occurred twice at each order.

A formal analysis of variance was developed for this complex design. Three versions of this were conducted. The first of these considered an analysis of the 120 means corresponding to the 120 sides (60 pigs x 2 sides). The second was an analysis of the 1120 observations for 20 pigs corresponding to pigs of one sex, while the third included the three gender groups and provided expected mean squares for each of the variance terms (n=3360 observations).

A number of sources of variability were taken into account in this analysis. Each of the 84 treatment combinations occurred in the design 40 times. Cooking effects were handled in the analysis as a 2 x 3 factorial + 1 (cooking method (roast or stir fry) x cut (Shoulder, loin or silverside) + loin steak. The appropriate standard errors for doing statistical tests/comparisons between the treatments were considered, however, this was complicated by the many sources of variability in this study. It was thought that pigs, even within the same sex, would differ from one another, however, the two sides within the same pig were not considered to differ as much, but differences between the packs within a side were expected as they were sourced from different primals. Furthermore, relatively small differences between the four samples within each cut x cooking method combination were expected. However, variability between sessions was expected due to each session involving different consumers as well as potential differences in preparing and serving samples to panelists. Variability between consumers was also expected as consumers were untrained.

As a result of these different sources of variability, components of the treatments occurred with different accuracy in different levels of the analysis. As each pair of sessions contained two pigs of the same sex, sex was applied to different sessions. The appropriate error to test for sex differences was a ‘between session’ variance. As samples within each session were cooked to the same level of final endpoint temperature, the effect of temperature was also estimated as a ‘between session’ variance. These two factors were estimated with less accuracy than ageing period and (cut x cooking method).

The effect of order of presentation of samples to consumers was addressed using analysis of variance. This analysis identified that 75% of the information on order effects was contained in the "within packs and Consumers" stratum, about 20% in the "between packs" stratum and another 5% in the other strata.

In summary, the constraints applied were:

- Each session used 2 sides, providing 56 samples.
- Each session used pork from a single sex. This was done to minimize any risk associated with boar taint from the entire male pigs affecting consumer assessment of samples from other sexes.
- A secondary constraint related to the cooking methods; each session needed to be done at a single level of endpoint temperature.
- As a result, pairs of carcases were used in a session. The two sessions were then created by taking the two sides which had the same temperature. In cases (i) and (ii) above, the two sides came from different pigs, while in case (iii), the two sides came from the same pig.
- Each pair of sessions contained two pigs of the same sex, so sex was always "applied" to different sessions. The appropriate error for testing sex differences was the "between session" variance. Also, as each session was conducted at the same level of temperature, the effect of endpoint temperature was estimated between sessions. Therefore, sex and endpoint temperature was estimated with less accuracy than ageing period and cut x cooking method.

Table 7 details the blocks (pairs of carcases and equivalently, pairs of sessions) that were allocated to each case and treatment levels that were confounded with this design.

Table 7: Allocation of pigs and sides within pigs to ageing and final endpoint temperature treatment and treatment levels (A – ageing period, T – temperature) that were confounded due to the design used

Case		i		ii		iii	
	Pig	1	2	1	2	1	2
Side	1	2d, 70°C	7d, 70°C	2d, 70°C	7d, 70°C	2d, 70°C	2d, 75°C
	2	7d, 75°C	2d, 75°C	2d, 75°C	7d, 75°C	7d, 70°C	7d, 75°C
Blocks - gender							
Entire males		1,4,5,9		6,10		2,3,7,8	
Females		12,13,15,16		17,18,19,20		11,14	
Castrates		21,22		23,24,26,28		25,27,29,30	
Confounded							
With sessions		T		T		T	
With pigs		AT		A		T	
Not confounded		A		AT		A, AT	

Regression analysis was used to predict overall liking of pork based on the four attributes of tenderness, aroma, juiciness and flavour. Regression analysis was also used to determine whether quality grading score and re-purchase intention could be predicted from sensory variables assessed in this study.

2.2 Smaller Sensory Studies

Two smaller sensory studies were also undertaken as part of this project. The methodology for these trials is reported below where they differed from the large sensory study. Details of the two studies are described in section 2.2.7.

The consumer sensory sessions were conducted at one central location; the SARDI Waite campus sensory laboratory. The loin was used for both studies, cut into steaks and the cooking method employed was grilling using the Silex grill to a medium degree of doneness (70°C).

2.2.1 Consumer Recruitment

Consumers were recruited by SARDI from various personnel and students who were based at the Waite campus from SARDI, CSIRO and the University of Adelaide. The specifications for recruitment were that all participants needed to be consumers who had eaten fresh pork (not bacon or ham) in the past month and who were aged between 18–65 years. Individuals were asked to join a panel of eight consumers for approximately 30 minutes at varying times of the day from 10.00 am to 4.00 pm. Three or four sessions were held per day.

Potential participants registered and were later contacted by a recruiter to arrange a time that would suit them to attend. Consumers were used only once in each study.

2.2.2 Allocation of Frozen Samples into Sensory Sessions

Frozen samples for the two studies were received by SARDI in January 2012 and stored at -18°C until required for sensory evaluation (August 2012). Samples were received as loin steaks, individually labelled and vacuum packed.

The samples were allocated into the individual sensory sessions by each study design. Approximately one week before the sensory sessions, the cartons of samples were removed from the freezer and the samples sorted into individual sessions, one carton per session and returned to storage at -18°C until approximately 48 hours prior to the testing day.

2.2.3 Sample Preparation

In the kitchen/preparation room the thawed loin steaks were removed from their cartons and the samples for Sessions 2 and 3 (and 4 on some days) were placed on trays on separate shelves in a domestic fridge (5°C) while preparation commenced with samples for Session 1. Each loin steak was identified by its unique number and this ID followed the sample from removal from preparation to presentation to the sensory panelist for evaluation.

2.2.4 Cooking Protocol

Approximately 20 minutes before the start of the sensory session, the grill was pre-heated to 160°C and cooking commenced. Cooking commenced approximately one hour before the start of the session due to the number of steaks required to be grilled for each session. In between each sensory session, the grill was switched off and the plates thoroughly cleaned.

2.2.5 Presentation Protocol

After two minutes resting on the cutting board, two steaks (grilled at the same time) were trimmed on all four sides to remove the fat and edges. For first lecithin study (refer to section 2.2.7.1), the centre piece of the steak was cut in half. The two halves were transferred with the ID label to a Pyrex holding container. Two different samples (four halves) were placed at opposite ends in an individual container. This process was repeated for the 16 steaks required in each sensory session.

For lecithin study (refer to 2.2.7.2) the centre piece of each steak was used for one consumer and once cut, transferred with its ID label to a Pyrex holding container, with up to three different samples in each container. This process was repeated for the 48 steaks required in each sensory session. The serving operation was completed in approximately 15 to 20 minutes per session.

2.2.6 Consumer Evaluation

Panelists manually recorded assessments on a paper questionnaire using the same questions and assessments as the large sensory study reported earlier in the report. The continuous line scales used in these studies were 15 cm in length, anchored at each end with words with right hand side equivalent to 100 and left hand side equivalent to 0 as the large study. Intensity values were not shown to the consumers.

The session was completed once all consumers had assessed and rated their samples. Once all the sensory sessions had been completed, the consumer assessment scores were entered into a spreadsheet and checked prior to data analysis. The ratings on the line scales were converted to 0-100 scale on entry.

2.2.7 Study designs and statistical analysis

2.2.7.1 Effect of lecithin treatment on meat quality, carcase quality and growth performance of female pigs.

This study involved consumer evaluation of pork loin steaks from 36 female pigs randomly allocated to one of four dietary treatments: 0, 4, 20 or 80 g/kg soy lecithin for five weeks. A total of 36 female pigs were assigned at random to each of the four treatments

The nine pigs per treatment produced four loin steaks per pig, a total of 36 steaks per treatment. Each steak was evaluated by two consumers so this created 72 half steaks or evaluations per treatment; 288 evaluations across all four treatments. Each consumer evaluated four samples from each of the four treatments in a session. A total of 72 consumers were recruited for this study, with eight consumers involved in each session.

An analysis of variance was conducted using the statistical package R (R version 2.14.0, http://www.r-project.org) to determine the effect of dietary treatment on eating quality attributes of pork. The analysis also allowed steak position on the loin to be assessed. Each session was divided into two half sessions, with four consumers in each half session. As half steaks were assessed, the first half-session contained one half steak from each of the 16 diet x position combinations, with the second half session, of identical layout to the first half session, using the second half steak. Each half session was designed as a Graeco-Latin square where the rows represented the sample presentation order to each consumer and the columns represented the four consumers (Table 8).

Table 8: Allocation of half steaks from each dietary treatment and steak position (dietary treatment, steak position) combination to consumers within a session

Presentation Order	Half session 1				Half session 2			
	Consumer				Consumer			
	1	2	3	4	1	2	3	4
1	1,1	2,4	4,3	3,2	1,1	2,4	4,3	3,2
2	2,2	1,3	3,4	4,1	2,2	1,3	3,4	4,1
3	3,3	4,2	2,1	1,4	3,3	4,2	2,1	1,4
4	4,4	3,1	1,2	2,3	4,4	3,1	1,2	2,3

2.2.7.2 Determining the effects of dietary lecithin and immunocastration on growth performance and carcase characteristics of group-housed finishing pigs.

This study involved consumer evaluation of pork samples from entire male, female and immunocastrated male pigs randomly allocated to a dietary treatment of 0 or 8 g/kg soy lecithin for five weeks. Ten pigs per treatment were used for this study.

A total of four loin steaks were obtained per pig; a total of 40 steaks per treatment. Each steak was evaluated by one consumer, resulting in 40 evaluations per treatment and 240 total evaluations across all six treatments. As each consumer evaluated six samples in a session from each of the six treatments, a total of 40 consumers were required for the study. Eight consumers were required per session. The analysis also allowed steak position on the loin to be assessed.

The final design used included a number of stratum – session, within pigs, within consumers and within loin. The main effects of dietary treatment, sex and their interaction had full efficiency in the within-consumers stratum. The residual term in the pigs within-sessions' stratum was used to test the sex and dietary treatments applied to pigs, while the presentation order effect, the loin steak position effects and interactions with sex and diet were tested against the residual in the stratum of both within-consumers and within-pigs.

3 Outcomes

3.1 Effect of sex, ageing period, muscle, cut type and endpoint temperature

3.1.1 Objective measurements

Entire male pigs were lighter at birth (P=0.021) and at the commencement of the finisher phase (P=0.028) than surgical castrate and female pigs, but full final liveweight and hot carcase weight was not influenced by sex of the pig (Table 9). Average daily gain, from both birth to finisher and from grower to finisher, was also not influenced by sex of the pig. However, both entire male and female carcases were leaner at the P2 site (P<0.001) than surgical castrates. The dressing percentage of carcases from entire male pigs was about 2% lower (P<0.001) compared with females and surgical castrates.

Table 9: Predicted means and standard error of the difference (s.e.d.) for effect of sex on liveweight at various stages of growth, average daily gain and carcase parameters

	Surgical Castrate	Entire male	Female	s.e.d.	P value
Birth weight (kg)	2.37	2.07	2.38	0.122	0.021
Grower- finisher weight	55.9	52.4	55.1	1.32	0.028
Full final liveweight (kg)	98.1	95.7	96.6	2.55	0.639
ADG (kg/day)					
Grower finisher	0.950	0.978	0.935	0.0435	0.610
Birth to finisher	0.648	0.634	0.635	0.017	0.648
P2 fat depth	14.8	9.8	10.3	0.85	<0.001
HCW (kg)	76.3	72.6	75.8	2.12	0.176
Estimated Trim 13 HSCW (kg)	69.4	66.0	68.9	1.93	0.176
Muscle depth (mm)	46.6	45.8	44.9	1.68	0.600
Dressing percentage (%)	77.65	75.82	78.48	0.609	<0.001
Chilling loss (%)	3.92	4.63	3.78	0.605	0.332
Cold carcase weight (kg)	66.7	62.9	66.3	1.88	0.103

Sex did not influence muscle pH of the loin measured from 45 min to 24 hours post-slaughter, however, muscle temperature measured at each time period was lower (P<0.001) in entire males than surgical castrates (Table 10). Carcase fatness at the P2 site was included in the analysis of variance to determine whether muscle temperature decline post-slaughter was influenced by carcase fat depth at the P2 site. Muscle temperature was higher in surgical castrates at 45 min (P<0.001), 3 h (P<0.001) and 6 h (P=0.002) post-slaughter when compared at a P2 fat depth of 11.6 mm.

Table 10: Predicted means and standard error of the difference (s.e.d) for effect of sex on muscle pH and temperature measured in the loin muscle at the P2 site (*M. longissimus thoracis et lumborum*) from 45 min to 24 h post-slaughter

	Surgical Castrate	Entire male	Female	s.e.d.	P value	P value covariate
pH						
45 min	6.50	6.37	6.47	0.069	0.154	
90 min	6.28	6.25	6.30	0.093	0.823	
3 hours	5.91	5.88	5.89	0.076	0.925	
6 hours	5.84	5.85	5.88	0.060	0.782	
24 hours	5.74	5.73	5.70	0.028	0.309	
Temperature						
45 min	31.68	27.14	27.63	0.834	<0.001	
90 min	22.76	20.01	21.72	0.698	<0.001	
3 hours	16.11	12.65	14.16	0.538	<0.001	
6 hours	9.57	6.79	8.08	0.434	<0.001	
24 hours	3.97	3.58	4.07	0.104	<0.001	
Means adjusted to a P2 fat depth of 11.60 mm, and s.e.d.						
Temperature						
45 min	31.44	27.55	27.47	0.764	<0.001	<0.001
90 min	21.80	20.56	22.13	0.768	0.058	0.005
3 hours	15.87	13.04	14.02	0.413	<0.001	<0.001
6 hours	8.91	7.17	8.36	0.469	0.002	0.002
24 hours	4.01	3.55	4.04	0.123	<0.001	0.363

Both sex and ageing period influenced muscle lightness and redness values of the loin muscle (Table 11). Pork from surgical castrates had a higher (P<0.001) content of intramuscular fat than females and entire males (4.00%, 2.99% and 2.47%, respectively). Overall, intramuscular fat levels of the loin ranged from 0.7 and 7.6%. For the silverside, ageing period influenced muscle lightness (P<0.001), redness (P<0.05) and yellowness (P<0.001).

For the blade, meat colour was darker (higher L* value; P<0.001) and redder (higher a* value; P<0.001) from female carcases than both entire male and surgical castrates. Ageing for 7 days increased both redness by 0.64 units (P=0.049) and yellowness (higher b* value; P<0.001) by 1.54 units compared to ageing for 2 days post-slaughter. Muscle lightness of the chuck tender was higher (P=0.014) from entire males compared with females and surgical castrates, redder (P<0.001) and yellower (P=0.004) from females compared with surgical castrates and entire males. As observed for the blade, redness (P=0.003) and yellowness (P<0.001) increased following ageing for 7 d compared with 2 d.

The sex x ageing period for muscle pH of the loin was found to be significant (P<0.001), however, these effects were not consistent. For the silverside, ageing for 7 d reduced (P<0.001) muscle pH by 0.07 pH units (5.51 and 5.44 (s.e.d. 0.013) for 2 and 7d aged silversides, respectively). The interaction between sex and ageing period was also significant for the silverside (P=0.044), with ageing for 7 d resulting in a consistent reduction in muscle pH for all three sexes but with greatest effect on entire males. Muscle pH of the blade was not influenced by sex or ageing period. Ageing period for 7 d post-slaughter reduced (P<0.05) muscle pH of the chuck tender by 0.05 units compared with ageing for 2 d post-slaughter. Drip loss of the loin was not influenced by either sex or ageing period, whilst ageing for 7 days reduced (P<0.001) drip loss of the silverside by 0.65% compared to 2 d aged muscles.

Table 11: Predicted means and standard error of the difference (s.e.d) for effect of sex (S) and ageing period (AP) on muscle pH and meat colour (L*, a*, b*) of the loin (*M. longissimus thoracis*), silverside (*M. gbiceps femoris*), blade *(M. triceps brachii*) and chuck tender (*M. supraspinatus*),

	Entire male		Female		Castrate		s.e.d.	P value
	2 d	7 d	2 d	7 d	2 d	7 d		
Loin								
pH	5.41	5.47	5.48	5.45	5.48	5.47	0.018	S - P-0.044; SxAP P<0.001
L	52.42	53.46	51.19	52.11	52.29	53.72	0.889	S – P=0.027; AP – P=0.021
a	4.50	4.75	5.39	6.15	4.49	4.83	0.460	S – P<0.001
b	2.44	3.12	2.24	3.16	2.19	3.46	0.314	AP - P<0.001
Drip loss	3.55	3.16	3.12	2.45	2.95	2.84	0.690	
IMF %	2.47		2.89		3.46		0.317	S – P=0.009
Silverside								
pH	5.53	5.42	5.50	5.45	5.50	5.45	0.022	AP – P<0.001; SxAP – P=0.044
L	49.71	51.22	48.36	50.15	49.61	51.06	0.790	S – P=0.04; AP P<0.001
a	7.07	7.64	7.30	7.73	6.83	7.46	0.432	AP – P=0.024
b	3.34	4.59	3.07	4.23	3.17	4.38	0.315	AP – P<0.001
Drip loss	2.48	1.91	2.80	1.83	2.10	1.76	0.296	AP – P<0.001
IMF %	1.76		2.15		2.79		0.283	S – P=0.002
Blade								
pH	5.61	5.57	5.62	5.64	5.67	5.58	0.051	
L value	44.83	46.17	43.19	42.53	44.23	44.61	0.470	S - P<0.001
a value	11.38	11.65	12.69	13.36	11.14	12.16	0.584	S - P<0.001, AP - P=0.049
b value	3.89	5.45	3.87	5.14	3.61	5.41	0.316	AP - P<0.001
IMF%	1.78		1.81		1.77		0.220	
Chuck tender								
pH	5.78	5.75	5.75	5.68	5.75	5.69	0.039	AP – P=0.016
L	43.82	43.60	42.43	42.65	42.56	41.71	0.548	S – P=0.014
a	14.58	15.13	15.72	16.21	14.14	15.31	0.423	S – P<0.001, AP – P=0.003
b	4.60	5.45	4.90	6.05	4.21	5.24	0.305	S – P=0.004, AP – P<0.001

Where #P<0.1, *P<0.05, **P<0.01, ***P<0.001

The intramuscular fat content of the loin was 0.99% lower (P=0.009) in entire males compared with surgical castrates (with females intermediate), whilst silversides from both entire males and female pigs were lower (P=0.002) than those from surgical castrates. No effect of sex was observed for the blade muscle from the shoulder.

Cooking pork to a final endpoint temperature of 75°C, rather than to 70°C, increased WBSF values for both the loin (40.87 vs. 36.85N, respectively; s.e.d. 2.812, P=0.01) and the silverside (36.65 vs. 33.42 N, sed 1.793, P=0.013) (Table 12). The influence of sex was close to significance (P+0.052) for the silverside, with WBSF values tending to be higher from entire males compared with castrates, with females intermediate. For cooking loss, cooking pork to a final endpoint temperature of 75°C, rather than to 70°C, increased cooking loss from the loin by 3.2% (21. 5 vs. 18.3%, respectively; sed 0.547; P<0.001) and by 2.6% for the silverside (22.6 vs. 20.0%, respectively; sed 0.531; P<0.001). Loins (P=0.005) and silversides (P=0.058) from entire males also had a higher cooking loss compared with females and castrates. The main effect of ageing was significant for cooking loss from the silverside (P=0.008), with cooking loss increasing by 1.44% compared with ageing for 2 d. The interaction between sex and final endpoint temperature for the silverside was also close to significance (P=0.057).

Table 12: Predicted means and standard error of the difference (s.e.d) for effect of sex (S), ageing period and endpoint temperature on Warner-Bratzler shear force (kg) and cooking loss from the loin and silverside muscles

	Entire male				Female				Castrate				s.e.d.	P value
	2d		7d		2d		7d		2d		7d			
	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C		
WBSF (N)														
Loin	41.94	40.47	36.65	40.77	37.93	44.00	34.69	39.30	35.28	38.81	34.50	41.85	4.312	T (P=0.01)
Silverside	34.79	39.59	33.22	39.98	33.52	37.34	36.26	35.77	30.09	30.67	32.54	36.36	3.205	S (P=0.052), T (P=0.013)
Cooking loss (%)														
Loin	19.75	23.75	20.20	23.91	17.97	19.52	17.93	21.08	15.80	20.64	18.01	19.80	1.520	S (P=0.005), T (P<0.001)
Silverside	21.06	22.10	22.77	23.94	20.62	21.64	19.45	23.26	16.69	21.35	19.42	23.28	1.444	S (P=0.058), AP (P=0.008), T (P<0.001), SxT (P=0.057)

3.1.2 Sensory results

Summary statistics across all treatments for sensory attributes of pork are presented in Table 13. Some consumers scored samples either 0 or 100 on the scale used in this study for all attributes and further analysis of data excluding these consumers may be required.

Table 13: Summary data for sensory attributes of cooked pork aroma, tenderness, juiciness, flavour and overall liking of pork (n=3360)

	Minimum	1st quartile	Median	Mean	SD	3rd quartile	Maximum
Aroma	0.5	42.5	62.0	59.12	23.35	77.5	100
Tenderness	0.0	29.5	54.0	52.57	27.70	76.0	100
Juiciness	0.0	32.0	55.5	53.33	26.67	75.0	100
Flavour	0.0	41.5	61.0	58.42	24.31	77.1	100
Overall liking	0.0	38.0	59.0	57.09	25.14	77.0	100

The correlation coefficients between sensory attributes for all consumer tastings is shown in Table 14. Flavour and overall liking were most highly correlated and aroma least correlated with the other four attributes.

Table 14: Correlation coefficients between sensory attributes for all consumer tastings (n=3360)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.302	1.000			
Juiciness	0.334	0.811	1.000		
Flavour	0.566	0.687	0.728	1.000	
Overall liking	0.489	0.808	0.816	0.905	1.000

The variance components of between session, between packs within a carcase, between sides, between pigs and between consumers were taken into consideration in the analysis (Table 15). Differences between sessions were not considered important as they were small in relation to differences between consumers. Variations between sides and between pigs were relatively small. Between consumer variability was large and consistent across all five variables. Measurement error, which measures the variability within individual consumers and the variability between samples within a pack, was also large. There were consumers who scored at or close to 0 or 100 for all seven samples that they evaluated. Large differences between consumers were found, with the standard deviation between consumer means of the order of 15 on the 0-100 point scale for each of the five key variables. Some of this may be attributable to treatment differences, as different consumers received different samples. As the quality variables of quality grade score and re-purchase intention were scored on a 1-5 scale, the variance components were much lower than those for the other five attributes.

Table 15: Variability within each variance component accounted for in the sensory analysis

	Variance component				
	Measurement	Packs	Sides	Pigs	Consumers
Aroma	330.97	11.30	0.00	0.00	172.18
Tenderness	455.16	44.20	0.00	8.43	158.76
Juiciness	396.67	44.17	4.50	2.04	175.27
Flavour	361.29	16.29	0.00	6.78	176.81
Overall liking	380.68	26.90	0.00	8.72	162.78
Quality grade	0.6818	0.0478	0.00	0.017	0.016
Re-purchase intention	1.0431	0.0717	0.00	0.027	0.234

The correlations between the sensory attributes evaluated in this study across consumers are shown in Table 16. These correlations are considerably higher than those obtained for all samples (refer to Table 14) which suggests that consumers tend to be either 'high scorers' or 'low scorers'. Overall, the highest correlation was found between flavour and overall liking.

Table 16: Correlation coefficients between sensory attributes across consumers (n=480)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.567	1.000			
Juiciness	0.599	0.853	1.000		
Flavour	0.755	0.745	0.802	1.000	
Overall liking	0.705	0.828	0.848	0.939	1.000

The strong relationship between the key variables was evidenced by the prediction equation for overall liking included the other four key variables (across all treatments):

Overall liking= -0.774 + 0.618xFlavour + 0.235xTenderness+ 0.156xJuiciness +0.019xAroma
All coefficients were statistically significant ($P<0.001$; SE 8.0).

Therefore, overall liking of pork was influenced, in order of importance, by flavour, tenderness, juiciness and aroma.

Across all 3360 samples assessed in this study, consumer responses for quality grade score and re-purchase intention are shown in Table 17. It was found that scores for quality grade score were slightly lower than for re-purchase intention.

Table 17: Matrix of panelist scores received for quality grade and re-purchase intention

Quality	Re-purchase intention				
grade score	1	2	3	4	5
1	106	7	0	0	0
2	145	380	32	0	0
3	7	194	728	326	11
4	6	3	58	584	337
5	0	0	0	22	414

Linear regression analysis of quality grade score with the five sensory attributes assessed in this study identified that overall liking was the most important variable influencing quality grade score. The equation was:

Quality grade score = 1.389 – 0.001 x Aroma + 0.003 x Tenderness + 0.004 x Flavour + 0.029 x Overall liking

As the coefficient for overall liking was larger than for all other sensory attributes, a regression analysis was then conducted, with only overall liking included in the analysis:

Quality grade score = 1.38 + 0.034 x Overall liking (SD 0.53, prediction accuracy 65%)

The relationship between re-purchase intention and the sensory attributes assessed was:

Re-purchase intention = 1.159 – 0.002 x Aroma + 0.004 x Tenderness + 0.001 x Flavour + 0.038 x Overall liking

As the coefficient for overall liking was larger than for tenderness and flavour, a regression analysis was then conducted including only overall liking in the analysis:

Re-purchase intention = 1.10 + 0.040 x Overall liking (SD 0.7, prediction accuracy 55%)

3.1.2.1 Sensory results

Pork from entire male pigs obtained lower scores for juiciness, flavour and overall liking than surgical castrates, with females intermediate (Table 18). The level of significance was highest for Flavour (P=0.017).

Table 18: Effect of sex, across all other treatment combinations, on eating quality attributes of pork

	Entire male	Female	Surgical castrate	s.e.d.	P value
Aroma	58.0	59.4	60.0	1.39	0.353
Tenderness	51.3	51.9	54.5	1.63	0.122
Juiciness	51.6	52.9	55.5	1.46	0.035
Flavour	56.6	57.9	60.8	1.41	0.017
Overall liking	55.2	56.6	59.5	1.45	0.018
Quality grade	3.32	3.34	3.39	0.057	0.026
Re-purchase intention	3.30	3.43	3.47	0.072	0.058

The main effects of both ageing period and cooking temperature, across all treatment combinations, were not significant. However, the interaction between ageing period and sex was significant for juiciness (P=0.014; Table 19), but the effects were not consistent. Although juiciness scores improved, albeit only slightly, for pork from females aged for 7 d rather than 2d, juiciness scores of 7d aged pork from entire males were reduced by 5.3 units compared to 2d pork.

Table 19: Effect of sex and ageing period on consumer scores for juiciness

Sex	Ageing period		s.e.d.	P
	2d	7d		
Entire male	54.2	48.9	0.867	0.014
Female	51.8	54.0		
Surgical castrate	55.0	56.0		

No effect of sex, ageing period, cut type or final endpoint temperature were found for aroma (Table 20), with differences only found for cooking method. The aroma scores for loin steaks was midway between those obtained for roast and stir fry (P=0.017). Overall, aroma scores for roasts were 12.2 units lower (P<0.0001) than stir-fry. The interaction between cut and cooking method (roast or stir fry) was also significant (P=0.019) Aroma of the pork loin steak was also influenced by final endpoint temperature (P=0.029).

Neither sex nor ageing period influenced consumer scores for tenderness (Table 21). Overall, cooking influenced tenderness and when separated into its factorial components, differences in tenderness scores were found due to cooking method (roast or stirfry), between steaks and all other cuts (P<0.00001) and for the factorial interaction between cut type and cooking method (roast or stir fry) (P<0.0001). For the shoulder and silverside, tenderness scores for roasts were lower than for stir fry (by 5.2 and 7.6 units, respectively) whilst for loins, consumer scores for tenderness of roasts were 2.84 units higher than for stirfry. When compared to the average of all other cuts, tenderness scores for loin steaks were lower. The interaction between final endpoint temperature and cooking method was also significant, but not consistent (P=0.014); roasts cooked to a endpoint temperature of 75°C obtained higher scores for tenderness than stir fry, but lower scores compared to stir fry when cooked to a endpoint temperature of 70°C.

Juiciness was influenced by sex of the pig, with surgical castrates producing juicier (P=0.035) pork than entire males, with females intermediate (Table 22). The main effect of cooking was also significant (P<0.0001). When cooking was separated into its factorial components, both cut type (P<0.0001) and cut type x cooking method (P=0.001) influenced juiciness scores. Juiciness scores for the shoulder cuts were 14.2, 18.9 and 27.8 units higher than the mean score for loin, silverside and loin steak, respectively. Loin steaks were less juicy (P<0.0001) when compared to the average tenderness score for all of the other cuts evaluated. Pork cooked as stir fry from both the shoulder and silverside was juicier than roasts from these primals (by 5.2 and 6.5 units, respectively), however for the loin, consumer scores for juiciness of roasts were 1.0 unit higher than for stir fry. Although the main effect of endpoint temperature did not influence juiciness scores of pork, the interaction between cut type and endpoint temperature was significant, with roasts cooked to 75°C judged as juicier than stir fry, whilst stir fry was juicier than roasts when cooked to 70°C.

Table 20: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for aroma

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	Average		
Entire male	2	70	55.95	63.76	52.45	69.04	59.80	59.54	70.89	*61.63*	1.133	C (P<0.0001)
	7	70	49.15	65.43	44.10	68.44	58.53	48.17	66.87	*57.24*		C_Stk (P=0.017)
	2	75	54.52	68.30	49.51	60.92	62.24	53.43	60.73	*58.52*		C_R (P<0.0001)
	7	75	44.71	62.05	45.94	59.64	53.63	51.02	65.15	*54.59*		C_Cut (P<0.0001)
Female	2	70	51.59	61.33	52.44	72.78	69.15	55.48	64.45	*61.03*		C_RxCut (P=0.009)
	7	70	57.23	63.15	48.85	64.93	65.09	52.43	65.16	*59.55*		TC_R (P=0.006)
	2	75	54.50	58.32	53.58	63.68	58.42	52.53	59.80	*57.26*		TC (P=0.076)
	7	75	51.20	67.49	56.66	70.49	59.40	50.33	62.06	*59.66*		AC_R (P=0.0024)
Surgical castrate	2	70	54.98	63.18	52.84	62.54	64.77	58.00	65.69	*60.28*		AC (P=0.073)
	7	70	50.59	65.19	47.28	70.37	66.07	53.79	63.21	*59.50*		
	2	75	55.81	63.16	55.61	65.59	54.80	57.50	69.96	*60.35*		
	7	75	56.31	63.30	52.60	67.08	62.88	55.30	61.45	*59.85*		
Average			*53.05*	*63.72*	*50.99*	*66.29*	*61.23*	*53.96*	*64.62*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 21: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for tenderness

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	*Average*		
Entire male	2	70	68.14	74.70	52.66	53.35	48.79	32.97	53.96	*54.94*	1.512	A (P=0.068)
	7	70	62.55	67.42	47.94	50.61	43.84	34.78	46.69	*50.55*		C (P<0.0001)
	2	75	68.71	70.22	52.09	50.31	35.66	38.29	47.53	*51.83*		C_Stk (P<0.0001)
	7	75	60.26	65.48	53.85	43.25	36.50	33.73	42.20	*47.89*		C_R (P=0.0008)
Female	2	70	64.82	68.71	58.37	57.82	45.85	37.20	41.96	*53.53*		C_Cut (P<0.0001)
	7	70	58.41	72.69	56.88	58.83	37.46	35.49	44.58	*52.05*		C_RxCut (P<0.0001)
	2	75	62.08	64.77	55.19	50.11	37.90	38.23	40.04	*49.76*		TC_R (P=0.014)
	7	75	59.66	68.13	56.93	52.97	40.96	38.84	47.61	*52.16*		
Surgical castrate	2	70	65.33	67.43	62.58	47.66	48.60	43.38	48.81	*54.83*		
	7	70	62.03	76.68	54.67	57.98	39.22	38.00	49.73	*54.04*		
	2	75	69.42	62.77	59.15	58.01	41.85	43.41	49.63	*54.89*		
	7	75	66.05	68.30	58.60	53.40	41.81	48.29	44.26	*54.39*		
Average			*63.95*	*68.94*	*55.74*	*52.86*	*41.54*	*38.55*	*46.42*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 22: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for juiciness

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	*Average*		
Entire male	2	70	70.59	74.13	50.63	54.66	42.54	40.95	56.77	*55.75*	1.356	S (P=0.035)
	7	70	61.31	66.42	41.81	45.85	41.33	35.47	52.86	*49.29*		AxS (P=0.021)
	2	75	68.88	71.06	53.67	50.52	31.69	43.09	50.07	*52.71*		C (P<0.0001)
	7	75	63.76	66.89	51.63	47.78	29.44	37.08	43.54	*48.59*		C_Stk (P<0.0001)
Female	2	70	62.53	70.10	58.39	56.96	42.17	42.64	50.48	*54.75*		C_R (P=0.0001)
	7	70	66.83	75.85	53.10	58.19	38.56	40.35	52.58	*55.07*		C_Cut (P<0.0001)
	2	75	55.99	64.52	51.68	49.55	33.57	41.10	45.77	*48.88*		C_RxCut (P=0.001)
	7	75	63.24	68.68	51.51	52.54	37.07	50.27	47.25	*52.94*		TC_Stk (P=0.027)
Surgical castrate	2	70	61.80	69.04	59.88	46.77	47.94	54.28	51.26	*55.85*		TC_R (P=0.010)
	7	70	61.71	75.83	56.88	58.79	44.11	48.07	59.69	*57.87*		TC (P=0.046)
	2	75	67.26	63.94	56.66	51.27	40.71	49.56	56.38	*55.11*		ATC_R (P=0.025)
	7	75	68.35	67.89	52.63	53.49	39.62	54.71	49.01	*55.10*		
Average			*64.35*	*69.53*	*53.21*	*52.20*	*39.06*	*44.80*	*51.30*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 23: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for flavour

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	*Average*		
Entire male	2	70	61.48	66.26	54.04	58.28	57.10	46.80	62.00	*57.99*	1.251	S (P=0.017)
	7	70	61.04	65.98	43.69	60.77	50.59	44.74	58.41	*55.03*		C (P<0.0001)
	2	75	64.70	72.15	54.76	54.76	50.79	48.93	54.82	*57.28*		C_Stk (P<0.0001)
	7	75	58.55	65.44	51.69	58.07	49.97	49.00	60.08	*56.11*		C_R (P=0.0001)
Female	2	70	57.74	69.42	54.93	64.57	56.20	44.93	57.33	*57.88*		C_Cut (P<0.0001)
	7	70	65.97	71.45	58.65	63.87	52.33	47.40	58.28	*59.71*		TC_Stk (P=0.027)
	2	75	56.85	66.23	60.43	58.12	47.24	49.29	53.39	*55.94*		
	7	75	59.81	71.29	55.51	64.30	52.11	48.77	54.30	*58.01*		
Surgical castrate	2	70	62.28	66.84	61.37	53.90	54.80	55.94	58.28	*59.06*		
	7	70	57.02	72.55	55.93	65.93	58.50	51.38	55.75	*59.58*		
	2	75	66.99	71.19	60.13	63.62	50.91	54.23	65.62	*61.81*		
	7	75	66.83	70.79	65.15	64.32	56.64	55.21	59.92	*62.69*		
Average			*61.61*	*69.13*	*56.36*	*60.88*	*53.10*	*49.72*	*58.18*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 24: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for overall liking

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	Average		
Entire male	2	70	61.05	68.62	50.77	55.67	52.26	41.53	58.85	*55.54*	1.304	S (P=0.018)
	7	70	61.72	67.95	44.36	56.02	47.82	39.54	52.67	*52.87*		C (P<0.0001)
	2	75	68.83	74.10	57.40	54.92	44.10	44.98	54.31	*56.95*		C_Stk (P<0.0001)
	7	75	64.10	68.50	53.78	54.17	44.39	47.89	55.31	*55.45*		C_R (P<0.0001)
Female	2	70	57.66	72.03	55.94	62.66	51.61	42.92	55.06	*56.84*		C_Cut (P<0.0001)
	7	70	65.41	71.92	58.14	60.62	47.72	43.54	54.22	*57.37*		C_RxCut (P=0.009)
	2	75	60.00	67.66	58.22	58.75	40.37	45.58	48.86	*54.21*		TC_Stk (P=0.006)
	7	75	61.32	73.44	57.92	62.62	49.72	47.98	52.15	*57.88*		TC_R (P=0.052)
Surgical castrate	2	70	62.77	66.86	62.31	51.95	53.60	55.00	57.46	*58.23*		TC (P=0.066)
	7	70	57.47	77.29	57.33	63.75	52.48	46.61	56.69	*58.46*		
	2	75	70.14	70.37	59.22	62.65	47.55	51.43	60.88	*60.03*		
	7	75	65.94	73.96	64.31	63.37	51.48	52.21	59.35	*61.23*		
Average			*63.03*	*71.06*	*56.64*	*58.93*	*48.59*	*46.60*	*54.75*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 25: Effect of sex (S), ageing period (A), endpoint temperature (T) and cooking (C) on consumer scores for quality grade score

Sex	Ageing period	Temp	Cooking treatment								s.e.d.	P value
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	Average		
Entire male	2	70	3.43	3.81	3.02	3.34	3.08	2.64	3.33	*3.24*	0.055	S (P=0.026)
	7	70	3.43	3.76	2.80	3.31	3.00	2.63	3.17	*3.16*		C (P<0.0001)
	2	75	3.83	4.04	3.34	3.28	2.75	2.78	3.18	*3.31*		C_Stk (P<0.0001)
	7	75	3.56	3.82	3.16	3.15	2.80	2.72	3.30	*3.21*		C_R (P<0.0001)
Female	2	70	3.65	4.20	3.46	3.76	3.32	2.93	3.44	*3.36*		C_Cut (P<0.0001)
	7	70	3.86	4.27	3.61	3.81	3.25	2.99	3.45	*3.43*		C_RxCut (P=0.006)
	2	75	3.57	3.88	3.48	3.56	3.00	3.03	3.17	*3.21*		TC_Stk (P=0.010)
	7	75	3.78	4.13	3.58	3.68	3.26	3.03	3.34	*3.37*		
Surgical castrate	2	70	3.64	3.85	3.60	2.98	3.30	3.16	3.19	*3.38*		
	7	70	3.53	4.09	3.32	3.62	3.15	2.91	3.20	*3.39*		
	2	75	3.74	3.96	3.35	3.40	2.86	3.02	3.25	*3.38*		
	7	75	3.57	3.92	3.43	3.53	2.99	3.09	3.30	*3.41*		
Average			*3.57*	*3.92*	*3.29*	*3.39*	*3.00*	*2.85*	*3.22*			

* Where: C compares the seven cuts evaluated

C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments

C_R allows for comparison between roast and stir fry cuts

C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)

TC allows for comparison between all seven cuts evaluated with endpoint temperature

TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature

TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Table 26: Effect of sex, ageing period, endpoint temperature, cut type and cooking method on consumer scores for re-purchase intention

Sex	Ageing period	Temp	Cut x cooking method								s.e.d.	P value*
			Blade	Chuck tender	Loin			Silverside				
			Roast	Stir fry	Roast	Stir fry	Steak	Roast	Stir fry	Average		
Entire male	2	70	3.49	4.04	2.97	3.44	3.23	2.54	3.53	*3.32*	0.070	S (P=0.058)
	7	70	3.64	3.86	2.98	3.34	3.05	2.59	3.15	*3.23*		AxS (P=0.05)
	2	75	3.95	4.20	3.45	3.41	2.73	2.83	3.21	*3.40*		C (P<0.0001)
	7	75	3.57	3.97	3.25	3.16	2.62	2.77	3.44	*3.25*		C_Stk (P<0.0001)
Female	2	70	3.70	4.21	3.55	3.64	3.20	2.72	3.36	*3.48*		C_R (P<0.0001)
	7	70	3.76	4.30	3.59	3.85	2.98	2.86	3.44	*3.54*		C_Cut (P<0.0001)
	2	75	3.52	3.66	3.44	3.39	2.72	2.86	3.05	*3.23*		C_RxCut (P=0.003)
	7	75	3.72	4.18	3.41	3.75	3.08	2.86	3.25	*3.46*		TC_Stk (P=0.010)
Surgical castrate	2	70	3.87	3.91	3.64	3.14	3.39	3.11	3.37	*3.49*		TC (P=0.062)
	7	70	3.53	4.21	3.51	3.64	3.16	2.96	3.28	*3.47*		
	2	75	3.94	4.12	3.49	3.52	2.93	3.02	3.24	*3.47*		
	7	75	3.73	4.15	3.56	3.65	2.77	3.00	3.31	*3.45*		
Average			*3.70*	*4.07*	*3.40*	*3.49*	*2.99*	*2.84*	*3.30*			

* Where: C compares the seven cuts evaluated
C_Stk allows for comparison between Loin Steak and average score of all other cut x cooking method treatments
C_R allows for comparison between roast and stir fry cuts
C_RxCut allows for comparison between cut (loin, silverside and shoulder) x cooking method (roast or stir fry)
TC allows for comparison between all seven cuts evaluated with endpoint temperature
TC_Stk – allows for comparison between Loin Steak and all other cut x cooking method treatments and endpoint temperature
TC_R – allows for comparison between roast and stir fry cuts and endpoint temperature

Flavour was influenced by sex of the pig (P=0.017); flavour scores of pork surgical castrates were 4.2 units higher than entire males, with females intermediate (Table 23). Cooking also influenced flavour and these cooking effects were due to cooking method (P<0.0001) and also cut type (P<0.0001). Flavour scores for the shoulder were higher than those for the loin, silverside and loin steak, by 6.8, 11.4 and 12.3 units respectively. Flavour scores for roasts were 6.8 units (P<0.0001) lower than for stir fry. The flavour of loin steaks were 6.2 units lower (P<0.0001) than the average flavour scores of all other cuts assessed in this study. The interaction between endpoint temperature for loin steaks was also significant (P=0.027), where flavour scores for loin steaks cooked to a 75°C internal temperature were 4.2 units lower than those cooked to 70°C. No effect of temperature was found for the other six cut x cooking method combinations.

Both sex (P=0.018) and the interaction term of cooking method x sex (P<0.0001) significantly influenced overall liking of pork loin steaks (Table 24). Overall liking scores for entire males were 4.3 units lower than those of castrated males, with females intermediate for this attribute. Both cut type (P<0.0001) and cooking method (P<0.0001) were also significant factors influencing overall liking of pork. Overall liking scores of loin steaks were 10.0 units lower than the average score of the other cut x cooking method combinations. When loin steaks were cooked to 75°C, overall liking scores were 4.7 units lower than when cooked to an internal temperature of 70°C. Overall liking scores for loin steaks were 11.6 units and 5.1 units lower than the other cut x cooking methods when cooked to 75°C or 70°C internal temperature, respectively.

Both sex (P=0.026) of the pig and cooking (P<0.0001) influenced quality grade scores of pork in this study (Table 25). The quality grade scores were 0.16 units (on a 1-5 grading scale) lower for pork from entire males than surgical castrates and 0.29 units lower than females. Differences between cut type (P<0.0001), cooking method (P<0.0001) and cut x cooking method (P=0.0063) were found. Overall, higher quality grade scores were obtained from cuts from the shoulder than roast and stir fry cuts from the loin and silverside stir fry, followed by loin steaks and lastly, silverside roasts. Overall, quality grade scores were 0.27 units higher for stir fry than for roasts. Quality grade scores of loin steaks were 0.37 units lower than the average score of the other cut x cooking method combinations. When cooked to an internal temperature of 75°C, quality grade scores of loin steaks were 0.50 units lower than the average of the other cut x cooking method combinations. Cooking to an internal temperature of 70°C reduced this difference between loin steaks and all other cuts x cooking method combinations to -0.24 units. Quality grade scores of loin steaks cooked to a endpoint temperature of 75°C were 0.18 units lower than when cooked to 70°C. Endpoint temperature did not affect quality grade scores of the other six cut x cooking method combinations.

The effect of sex was close to significance (P=0.053) for re-purchase intention; re-purchase intention scores for pork from entire males were 0.17 units lower than surgical castrates and 0.13 units lower than females (Table 26). As shown for quality grade score, re-purchase intention scores varied between cuts (P<0.0001), with pork from shoulders obtaining higher re-purchase intention scores than those from the loin and the silverside. On a cut x cooking method basis, silverside roasts and loin steaks had the lowest scores for re-purchase intention. Average re-purchase intention scores for stir fry cuts were 0.31 units higher (P<0.0001) than roasts and 0.63 units higher than loin steaks. When cooked to an internal temperature of 75°C, re-purchase intention scores of loin steaks were 0.67 units lower (P=0.0021) than the average of the other cut x cooking method combinations. Cooking to an internal temperature of 70°C reduced this difference between loin steaks and all other cuts x cooking method combinations by 0.30 units. Re-purchase intention scores of loin steaks cooked to a endpoint temperature of 75°C were 0.24 units lower than when cooked to 70°C. Endpoint temperature did not affect re-purchase intention scores of the other six cut x cooking method combinations.

The percentage of pork samples that obtained scores of less than 3 for quality grade (fail rate) and re-purchase intention scores of less than 3 (fail rate) for each sex is shown in Table 27. Overall, the fail rate of pork from entire males was 4% higher than for pork from females and 5.3% higher than for surgical castrates. The percentage of evaluations of pork from entire males that were rated as either 1 or 2 (I definitely would not buy it' or 'I would probably not buy it') for re-purchase intention was 5% higher than for pork from both females and surgical castrates.

Table 27: Percentage of consumer scores for quality grade and re-purchase intention for pork from entire males, females and surgical castrates, across all treatments (n=1120 evaluations per row)

	Quality grade score					Fail rate
	1	2	3	4	5	(% <3)
Entire males	4.1	18.9	37.4	28.9	10.6	23.0
Females	2.1	16.7	36.8	31.8	12.3	19.1
Surgical castrates	3.8	13.8	38.8	27.5	16.0	17.7
	Re-purchase intention score					Would not
	1	2	3	4	5	purchase(%<3)
Entire males	9.1	19.6	24.2	26.5	20.6	28.7
Females	6.4	17.2	24.4	30.1	21.7	23.6
Surgical castrates	8.1	15.4	24.5	26.6	25.5	23.5

The fail rates for each cut x cooking method combination taking into account sex of the pig, ageing period and endpoint temperature are presented for quality grade scores in Table 28 and re-purchase intention in Table 29.

Table 28: Percentage of consumer scores for quality grade for pork from different cuts and cooking method, sexes (entire males, females and surgical castrates), ageing period (2 or 7d) and endpoint temperature (70 or 75C) (n=40 evaluations per column within cut)

	Quality grade score	Entire male				Female				Surgical castrate				Overall Fail rate (<%3) for each cut
		2d		7d		2d		7d		2d		7d		
		70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	
Shoulder (Blade) Roast														
	1	5	0	2.5	7.5	5	5	0	0	2.5	0	0	2.5	
	2	7.5	2.5	12.5	5	10	7.5	10	5	10	5	5	10	
	3	42.5	32.5	32.5	35	30	42.5	35	37.5	32.5	45	37.5	32.5	
	4	30	45	37.5	37.5	37.5	30	30	47.5	25	32.5	47.5	25	
	5	15	20	15	15	17.5	15	25	10	30	17.5	10	30	
Fail rate (%<3)		*12.5*	*2.5*	*15.0*	*12.5*	*15*	*12.5*	*10*	*5*	*12.5*	*5*	*5*	*12.5*	*12.1*
Shoulder (Chuck tender) stir fry														
	1	0	0	0	0	0	5	0	0	5	0	2.5	0	
	2	7.5	2.5	2.5	12.5	5	7.5	2.5	0	2.5	7.5	0	2.5	
	3	30	25	45	20	12.5	15	20	37.5	25	20	22.5	37.5	
	4	27.5	40	32.5	45	45	50	45	40	27.5	35	37.5	35	
	5	35	32.5	20	22.5	37.5	22.5	32.5	22.5	40	37.5	37.5	25	
Fail rate (%<3)		*7.5*	*2.5*	*2.5*	*12.5*	*5*	*12.5*	*2.5*	*0*	*7.5*	*7.5*	*2.5*	*2.5*	*5.4*
Loin Roast														
	1	5	0	5	0	5	0	0	0	0	2.5	5	2.5	
	2	30	17.5	25	27.5	20	17.5	10	12.5	12.5	15	7.5	10	
	3	35	35	52.5	40	25	37.5	40	55	35	40	37.5	52.5	
	4	17.5	32.5	15	30	37.5	37.5	37.5	22.5	40	32.5	30	20	
	5	12.5	15	2.5	2.5	12.5	7.5	12.5	10	12.5	10	20	15	
Fail rate (%<3)		*35*	*17.5*	*30*	*27.5*	*25*	*17.5*	*10*	*12.5*	*12.5*	*17.5*	*12.5*	*12.5*	*19.2*
Loin Stir Fry														
	1	2.5	0	0	5	0	0	0	2.5	7.5	2.5	2.5	0	
	2	15	22.5	12.5	15	12.5	12.5	7.5	7.5	25	12.5	2.5	15	
	3	37.5	32.5	45	45	35	47.5	32.5	40	42.5	52.5	45	32.5	
	4	32.5	35	40	32.5	37.5	27.5	40	42.5	20	22.5	22.5	37.5	
	5	12.5	10	2.5	2.5	15	12.5	20	7.5	5	10	27.5	15	
Fail rate (%<3)		*17.5*	*22.5*	*12.5*	*20*	*12.5*	*12.5*	*7.5*	*10*	*32.5*	*15*	*5*	*15*	*15.2*

Loin Steak														
	1	10	7.5	5	10	2.5	2.5	0	7.5	7.5	15	2.5	7.5	
	2	22.5	27.5	12.5	30	27.5	30	27.5	35	10	22.5	10	30	
	3	30	47.5	50	40	32.5	45	45	25	37.5	37.5	52.5	30	
	4	27.5	15	25	17.5	22.5	17.5	17.5	20	35	15	27.5	25	
	5	10	2.5	7.5	2.5	15	5	10	12.5	10	10	7.5	7.5	
Fail rate (%<3)		*32.5*	*35*	*17.5*	*40*	*30*	*32.5*	*27.5*	*42.5*	*17.5*	*37.5*	*12.5*	*37.5*	*30.2*
Silverside Roast														
	1	15	7.5	7.5	2.5	7.5	5	0	2.5	5	5	7.5	2.5	
	2	27.5	30	37.5	45	35	30	30	32.5	25	25	25	22.5	
	3	40	45	40	37.5	37.5	50	50	37.5	30	45	40	55	
	4	12.5	17.5	12.5	15	17.5	15	20	25	30	17.5	20	15	
	5	5	0	2.5	0	2.5	0	0	2.5	10	7.5	7.5	5	
Fail rate (%<3)		*42.5*	*37.5*	*45*	*47.5*	*42.5*	*35*	*30*	*35*	*30*	*30*	*32.5*	*25*	*36.0*
Silverside Stir Fry														
	1	5	10	0	2.5	0	5	5	2.5	5	0	7.5	2.5	21.5
	2	17.5	10	27.5	25	10	27.5	15	15	15	20	12.5	17.5	
	3	32.5	32.5	37.5	30	52.5	37.5	42.5	47.5	42.5	52.5	37.5	42.5	
	4	30	42.5	25	40	32.5	25	25	30	32.5	17.5	37.5	30	
	5	15	5	10	2.5	5	5	12.5	5	5	10	5	7.5	
Fail rate (%<3)		*22.5*	*20*	*27.5*	*27.5*	*10*	*32.5*	*20*	*17.5*	*20*	*20*	*20*	*20*	*21.5*

Table 29: Percentage of consumer scores for re-purchase intention for pork from different cut types, cooking method, sexes (entire males, females and surgical castrates), ageing period (2 or 7d) and endpoint temperature (70 or 75C) (n=40 evaluations per column within cut)

Quality grade score	Entire male				Female				Surgical castrate				Overall would not buy (<%3) for each cut
	2d		7d		2d		7d		2d		7d		
	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	70°C	75°C	
Shoulder (Blade) Roast													
1	5	2.5	2.5	12.5	5	12.5	2.5	5	7.5	2.5	5	7.5	
2	15	22.5	25	27.5	15	17.5	15	30	7.5	15	30	7.5	
3	35	22.5	22.5	22.5	25	27.5	27.5	17.5	17.5	25	17.5	17.5	
4	20	30	30	27.5	35	22.5	20	20	27.5	32.5	20	27.5	
5	25	22.5	20	10	20	20	35	27.5	40	25	27.5	40	
Fail rate (%<3)	*20*	*25*	*27.5*	*40*	*20*	*30*	*17.5*	*35*	*15*	*17.5*	*35*	*15*	*24.8*
Shoulder (chuck tender) stir fry													
1	2.5	12.5	10	15	2.5	10	5	2.5	7.5	2.5	7.5	7.5	
2	5	27.5	32.5	15	10	20	12.5	22.5	10	17.5	7.5	25	
3	17.5	12.5	32.5	30	20	27.5	22.5	22.5	27.5	45	32.5	25	
4	27.5	27.5	22.5	30	35	27.5	32.5	45	40	15	25	27.5	
5	47.5	20	2.5	10	32.5	15	27.5	7.5	15	20	27.5	15	
Fail rate (%<3)	*7.5*	*40*	*42.5*	*30*	*12.5*	*30*	*17.5*	*25*	*17.5*	*20*	*15*	*32.5*	*24.2*
Loin Roast													
1	20	2.5	7.5	10	2.5	2.5	5	5	10	7.5	10	10	
2	25	25	12.5	20	7.5	15	17.5	17.5	15	37.5	17.5	12.5	
3	12.5	15	20	17.5	30	37.5	40	32.5	32.5	22.5	17.5	25	
4	22.5	27.5	22.5	42.5	37.5	30	17.5	37.5	17.5	22.5	22.5	25	
5	20	30	37.5	10	22.5	15	20	7.5	25	10	32.5	27.5	
Fail rate (%<3)	*45*	*27.5*	*20*	*30*	*10*	*17.5*	*22.5*	*22.5*	*25*	*45*	*27.5*	*22.5*	*26.3*
Loin Stir Fry													
1	5	5	20	10	12.5	7.5	2.5	2.5	5	12.5	5	10	
2	20	17.5	10	20	17.5	25	22.5	20	17.5	15	15	22.5	
3	27.5	25	30	22.5	10	40	35	22.5	15	17.5	17.5	22.5	
4	17.5	30	17.5	40	35	27.5	25	40	32.5	40	32.5	27.5	

5	30	22.5	22.5	7.5	25	0	15	15	30	15	30	17.5	
Fail rate (%<3)	*25*	*22.5*	*30*	*30*	*30*	*32.5*	*25*	*22.5*	*22.5*	*27.5*	*20*	*32.5*	*26.7*
Loin steak													
1	12.5	7.5	10	5	10	2.5	12.5	7.5	15	7.5	5	7.5	
2	22.5	12.5	15	30	22.5	15	12.5	5	7.5	10	7.5	7.5	
3	20	22.5	32.5	20	17.5	17.5	20	27.5	27.5	22.5	30	30	
4	27.5	30	25	20	27.5	45	40	30	22.5	30	37.5	25	
5	17.5	27.5	17.5	25	22.5	20	15	30	27.5	30	20	30	
Fail rate (%<3)	*35*	*20*	*25*	*35*	*32.5*	*17.5*	*25*	*12.5*	*22.5*	*17.5*	*12.5*	*15*	*22.5*
Silverside Roast													
1	30	2.5	2.5	7.5	12.5	10	2.5	10	5	17.5	10	5	
2	20	10	22.5	15	15	35	7.5	32.5	20	15	5	22.5	
3	30	35	20	27.5	22.5	25	17.5	17.5	22.5	22.5	37.5	12.5	
4	7.5	22.5	37.5	32.5	30	12.5	25	32.5	25	20	30	37.5	
5	12.5	30	17.5	17.5	20	17.5	47.5	7.5	27.5	25	17.5	22.5	
Fail rate (%<3)	*50*	*12.5*	*25*	*22.5*	*22.5*	*45*	*10*	*42.5*	*25*	*32.5*	*15*	*27.5*	*27.9*
Silverside Stir Fry													
1	7.5	15	2.5	10	7.5	7.5	2.5	7.5	12.5	7.5	2.5	10	
2	20	17.5	15	27.5	15	20	5	12.5	15	12.5	25	15	
3	20	15	37.5	32.5	27.5	12.5	20	20	27.5	17.5	15	20	
4	22.5	30	37.5	15	30	22.5	37.5	22.5	17.5	25	22.5	17.5	
5	30	22.5	7.5	15	20	37.5	35	37.5	27.5	37.5	35	37.5	
Fail rate (%<3)	*27.5*	*32.5*	*17.5*	*37.5*	*22.5*	*27.5*	*7.5*	*20*	*27.5*	*20*	*27.5*	*25*	*24.4*

For all variables considered, a strong effect of order was found (Table 30). Average tenderness was scored higher (P<0.0001) by 17 units, by 5.6 units for flavour, 9.4 units for juiciness and 8.2 units for overall liking from presentation order 1 to 7. Although presentation order influenced aroma scores (P=0.017), the relationship was not linear. Both quality grade score and re-purchase intention scores increased linearly due to presentation order. It is important to note that the sensory design used for allocation of samples from different cuts and cooking methods to consumer panelists with respect to tasting order was fully randomized to ensure that presentation order effects would not influence results obtained for the different cut x cooking method combinations.

Table 30: Effect of presentation order on sensory scores obtained for pork by consumers.

	Presentation Order							s.e.d.	P value
	I	2	3	4	5	6	7		
Aroma	54.86	51.67	53.18	51.55	50.97	53.36	52.39	1.36	P=0.017
Juiciness	47.27	49.71	52.13	53.63	54.36	54.25	56.64	1.51	P<0.0001
Tenderness	42.29	49.25	53.30	53.64	55.37	56.13	59.46	1.45	P<0.0001
Flavour	56.52	55.67	58.99	58.53	57.75	59.28	62.19	1.40	P<0.0001
Overall liking	53.19	54.94	57.28	57.71	57.10	58.04	61.37	1.44	P<0.0001
Quality grade	3.12	3.26	3.28	3.33	3.34	3.40	3.51	0.061	P<0.0001
Re-purchase intention	3.18	3.34	3.37	3.41	3.39	3.47	3.63	0.075	P<0.0001

3.2 Effect of lecithin treatment on sensory quality of loin steaks from female pigs

The average sensory scores for the five key variables varied from 42.9 to 59.4 and the summary statistics across all treatments are presented in Table 31.

Table 31: Summary statistics for sensory attributes assessed in this study

	Minimum	1st quartile	Median	Mean	SD	3rd quartile	Maximum
Aroma	10.2	49.82	59.65	59.43	16.62	72.00	98.7
Tenderness	0.0	24.52	45.00	43.45	23.55	61.47	98.0
Juiciness	0.0	22.52	45.00	42.92	24.15	62.00	98.0
Flavour	0.0	45.30	59.30	56.64	19.10	70.70	100.0
Overall liking	0.0	38.70	54.70	52.20	20.54	66.70	93.3
Quality grade	1.0	2.00	3.00	2.97	0.95	4.00	5.0
Re-purchase intention	1.0	2.00	3.00	3.00	1.15	4.00	5.0

The level of soy lecithin in the diet of finisher pigs did not influence any of the sensory attributes assessed in this study (Table 32). Although not significant, average scores for all attributes (except tenderness) were higher for pork from pigs fed the control diet.

Table 32: Effect of dietary soy lecithin concentration on consumer sensory scores of pork loin steaks

	Dietary soy lecithin concentration				s.e.d.	P value
	0	5	20	80		
Aroma	60.4	59.8	59.1	58.3	3.2	0.919
Tenderness	48.1	38.9	43.1	43.6	5.8	0.488
Juiciness	45.0	39.0	39.0	48.7	5.1	0.189
Flavour	60.4	55.2	54.0	57.0	4.4	0.501
Overall liking	56.8	49.0	49.9	53.1	5.4	0.474
Quality grade	3.26	2.81	2.88	2.94	0.24	0.260
Re-purchase intention	3.26	2.83	2.94	2.97	0.28	0.482

Presentation order influenced both tenderness and overall liking (Table 33). Lower ($P<0.001$) sensory scores for tenderness were obtained for steaks that were tasted first. Similar findings were observed for overall liking, with steaks assessed first obtaining lower scores than those assessed second and fourth, with those tested third intermediate. Overall liking increased by 7 units from presentation order 1 to 4.

Table 33: Effect of order of presentation on consumer sensory scores of pork loin steaks

	Order of presentation				s.e.d.	P value
	1	2	3	4		
Aroma	62.5	58.5	59.1	57.6	2.2	0.126
Tenderness	33.2	47.6	44.0	49.0	3.1	0.000
Juiciness	40.0	47.5	40.6	43.5	3.6	0.152
Flavour	53.9	59.3	56.5	56.8	2.5	0.199
Overall liking	47.7	54.7	51.6	54.8	2.7	0.034
Quality grade	2.82	3.03	3.01	3.03	0.18	
Re-purchase intention	2.76	3.07	3.08	3.10	0.22	

The effect of position along the loin where the steak was obtained did not affect consumer sensory scores (Table 34).

Table 34: Effect of loin steak position on consumer sensory scores

	Position of steak (cutting commencing from caudal end of loin)				s.e.d.	P value
	Site 1	2	3	4		
Aroma	57.9	60.9	60.0	58.9	2.2	0.531
Tenderness	42.3	42.1	44.7	44.5	3.1	0.749
Juiciness	40.1	41.2	44.5	45.9	3.6	0.337
Flavour	54.2	58.1	58.1	56.2	2.5	0.329
Overall liking	51.2	51.4	52.6	53.6	2.7	0.794
Quality grade	2.85	2.97	3.06	3.01	0.18	0.415
Re-purchase intention	2.83	3.03	3.10	3.06	0.22	0.346

The correlation matrix between sensory variables for all consumer evaluations made on samples in this study showed that overall liking was highly correlated with flavour, followed by tenderness, juiciness and aroma (Table 35).

Table 35: Correlation matrix between sensory variables for all consumer evaluations (n=288)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.270	1.000			
Juiciness	0.171	0.662	1.000		
Flavour	0.458	0.619	0.513	1.000	
Overall liking	0.445	0.798	0.667	0.841	1.000

The correlations between the 40 Consumer means across the five key variables were generally larger than those seen for all 288 data points (Table 36).

Table 36: Correlation matrix between sensory variables using consumer means (n=40)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.330	1.000			
Juiciness	0.160	0.771	1.000		
Flavour	0.508	0.578	0.453	1.000	
Overall liking	0.521	0.784	0.684	0.823	1.000

Linear regression analysis of overall liking using the other four sensory variables identified the relationship:

$$\text{Overall liking} = -4.3+0.528*\text{Flavour}+0.317*\text{Tenderness}+0.136*\text{Juiciness}+0.118*\text{Aroma}$$
(SD 8.0)

Overall, quality grade and re-purchase intention were found to be most strongly related to overall liking ($P<0.0001$).

Linear regression analysis of quality grade score, on a 1-5 scale, against overall liking identified that:

$$\text{Quality grade} = 0.92+0.039*\text{Overall liking}$$

whilst the equation for repurchase intention, on a 1-5 scale, was:

Re-purchase intention = 0.58+0.046*Overall liking

Table 37 shows that quality grade and re-purchase intention score were closely related. These scores agreed 195 times out of 288 (68%). Re-purchase intention tended to be more spread towards the ends of the 1-5 scale than quality grade score.

Table 37: Matrix of panelist scores for each sample evaluated for quality grade and re-purchase intention

Quality grade score	Re-purchase intention score				
	1	2	3	4	5
1	15	0	0	0	0
2	15	44	8	0	0
3	1	22	77	32	0
4	0	1	1	42	11
5	0	0	0	1	17

The fail rate of pork loin steaks in this study (denoting the percentage of consumer tastings that were scored either 1 or 2 for quality grade) was high and relatively similar across all treatments, ranging from 25-32% (Table 38). This indicates that soy lecithin supplementation of pigs does not result in improved consumer appreciation of pork loin steaks when cooked to an internal temperature of 70°C.

Table 38: Effect of diet (control, 5,20 or 80g/kg soy lecithin) on quality grade scores obtained from consumers for pork loin steaks (n=72 tastings per diet).

Diet	Quality grade score					Fail rate
	1	2	3	4	5	(% <3)
Control	4.2	22.2	44.4	22.2	6.9	26.4
5 g/kg soy lecithin	6.9	25.0	40.3	23.6	4.2	31.9
20 g/kg soy lecithin	2.8	22.2	58.3	13.9	2.8	25
80 g/kg soy lecithin	8.3	23.6	40.3	16.7	11.1	31.9

Furthermore, the inclusion of soy lecithin in the diet of pigs as a means of improving sensory quality did not result in favourable scores for re-purchase intention, with 37% of evaluations for loins from soy lecithin fed pigs obtaining a score of 1 or 2 for re-purchase intention compared with 26% for control animals (Table 39).

Table 39: Effect of diet on consumer re-purchase intention scores of pork loin steaks (n=72 tastings per diet).

	Re-purchase intention					Would not buy
	1	2	3	4	5	(% <3)
Control	6.9	19.4	30.6	26.4	16.7	26.4
5 g/kg soy lecithin	18.1	22.2	27.8	22.2	9.7	40.3
20 g/kg soy lecithin	9.7	29.2	25.0	29.2	6.9	38.9
80 g/kg soy lecithin	8.3	23.6	36.1	26.4	5.6	31.9

3.3 Determining the effects of dietary lecithin and immunocastration on sensory quality of group-housed finishing pigs.

The average sensory scores for the five key variables varied from 50.4 to 62.3 (Table 40).

Table 40: Summary statistics for sensory attributes assessed in this study

	Minimum	1st quartile	Median	Mean	SD	3rd quartile	Maximum
Aroma	12.7	50.53	62.7	62.28	17.59	75.3	100.0
Tenderness	0.7	39.30	57.3	54.82	23.37	73.3	99.3
Juiciness	0.7	30.70	53.3	50.44	24.32	68.0	100.0
Flavour	1.3	50.70	63.3	59.91	20.48	74.7	97.3
Overall liking	0.7	46.70	60.7	58.50	20.36	73.3	98.0
Quality grade	1.0	3.00	3.0	3.23	1.00	4.0	5.0
Re-purchase intention	1.0	2.00	3.0	3.28	1.23	4.0	5.0

The correlation matrix between sensory variables is shown in Table 41.

Table 41: Correlation matrix between sensory variables for all consumer evaluations (n=240)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.284	1.000			
Juiciness	0.232	0.733	1.000		
Flavour	0.516	0.614	0.566	1.000	
Overall liking	0.470	0.742	0.715	0.875	1.000

The correlations between the 40 consumer means across the five key variables tended to be larger than those seen for all 240 data points (Table 42). This was considered to be due to the averaging process which reduced measurement error and highlighted the idiosyncrasies of individual consumers.

Table 42: Correlation matrix between sensory variables using consumer means (n=40)

	Aroma	Tenderness	Juiciness	Flavour	Overall liking
Aroma	1.000				
Tenderness	0.420	1.000			
Juiciness	0.296	0.881	1.000		
Flavour	0.665	0.716	0.577	1.000	
Overall liking	0.589	0.801	0.737	0.912	1.000

Linear regression analysis to predict overall liking using the other four sensory variables identified the relationship:

$$\text{Overall liking} = -0.2+0.601*\text{Flavour}+0.173*\text{Tenderness}+0.180*\text{Juiciness}+0.060*\text{Aroma}, \quad (\text{SD } 7.8)$$

Quality grade score and re-purchase intention were closely related (Table 43).

Table 43: Matrix of panelist scores received for quality grade and re-purchase intention

Quality grade score	Re-purchase intention score				
	1	2	3	4	5
1	11	0	0	0	0
2	10	32	1	0	0
3	0	15	56	19	0
4	0	1	4	43	25
5	0	0	0	0	21

These scores agreed 163 times out of 240 (68%). Re-purchase intention tended to be spread more towards the ends of the 1-5 scale than quality grade score.

Quality grade and re-purchase intention were most strongly related to overall liking scores. Regression analysis for quality grade score against overall liking derived the relationship:

$$\text{Quality grade} = 0.78+0.042*\text{Overall liking}$$

and the equation for repurchase intention, on a 1-5 scale, was:

$$\text{Re-purchase intention} = 0.32+0.051*\text{Overall liking}$$

Neither sex nor diet were significant for any of the sensory variables assessed in this study (Table 44). The interaction between sex of the pig and diet was also not significant. This may be due to with a larger variation between pigs in this study, implying that much larger differences between treatments would be needed (e.g. of the order of 10 points on the 0-100 scale) for significance to be achieved. Nevertheless, pork from entire males had lower scores for flavour and overall liking than steaks from females.

Table 44: Sensory scores for pork loin steaks for the interaction between sex x diet

Sex	Entire male		Female		Immunocastrate		P value
Diet	Control	Lecithin	Control	Lecithin	Control	Lecithin	
Aroma	62.9	61.3	63.2	63.8	59.3	63.1	0.646
Tenderness	58.2	52.1	47.8	59.5	55.7	55.6	0.098
Juiciness	52.7	49.6	48.4	54.2	48.7	49.1	0.546
Flavour	58.0	53.6	61.3	64.9	60.1	61.4	0.251
Overall liking	57.5	54.6	58.2	61.8	57.8	61.2	0.295
Quality grade	3.23	3.02	3.05	3.45	3.25	3.35	0.170
Re-purchase intention	3.30	2.90	3.20	3.58	3.27	3.40	0.144

The fail rate of pork loin steaks in this study was reduced by 10% by the inclusion of soy lecithin at 8 g/kg feed (Table 45). The fail rate of pork steaks from entire males fed soy lecithin was 15% greater than those from females and immunocastrates fed the same dietary treatment.

Table 45: Effect of dietary treatment (control, C; lecithin, L) on quality grade scores obtained from consumers for pork loin steaks (n=72 tastings per diet).

Quality grade score	Entire male		Female		Immunocastrate		Fail rate
	Control	Lecithin	Control	Lecithin	Control	Lecithin	%<3
1	10	5	7.5	5	0	0	C 27.5%
2	17.5	22.5	20	7.5	27.5	12.5	L 17.5%
3	27.5	47.5	40	40	25	45	
4	30	15	25	32.5	42.5	37.5	
5	15	10	7.5	15	5	5	

Similarly for re-purchase intention, soy lecithin supplementation to pigs, regardless of sex, improved re-purchase intention ratings by consumers (Table 46).

Table 46: Effect of diet on re-purchase intention scores obtained from consumers for pork loin steaks (n=40 tastings per diet).

Re-purchase intention score	Entire male		Female		Immunocastrate		Would not
	Control	Lecithin	Control	Lecithin	Control	Lecithin	buy (%<3)
1	15	15	10	5	7.5	5	C 31.7
2	12.5	12.5	22.5	12.5	27.5	15	L 21.7
3	22.5	22.5	25	27.5	15	30	
4	27.5	27.5	22.5	30	30	35	
5	22.5	22.5	20	25	20	15	

Presentation order influenced sensory scores for aroma (Table 47, P=0.002), declining linearly with increasing presentation order. Similar findings were observed for flavour and overall liking, but differences due to order were not significant due to larger standard errors.

Table 47: Effect of order of presentation of loin steaks to panelists on sensory scores

	Presentation order						s.e.d.	P value
	1	2	3	4	5	6		
Aroma	68.4	62.8	59.5	61.4	63.0	58.6	3.1	0.002
Tenderness	58.6	57.5	54.2	54.7	54.2	49.7	3.6	0.700
Juiciness	52.2	56.0	52.0	48.4	46.1	48.0	4.3	0.296
Flavour	64.3	60.2	57.8	63.1	58.1	55.9	3.6	0.372
Overall liking	65.3	61.7	57.1	58.2	54.2	54.5	3.6	0.116
Quality grade	3.50	3.42	3.17	3.23	3.08	2.95	0.19	0.246
Re-purchase intention	3.70	3.45	3.25	3.25	3.02	2.98	0.22	0.104

No differences due to the location site of the loin steak within the loin muscle was found (Table 48). Each steak was cut to a thickness of 2.5 cm thick and steaks were prepared from the caudal end of the *M. longissimus dorsi* and numbered from 1 (most caudal end)to 4 (most cranial end).

Table 48: Effect of position of the loin steak within the loin on sensory attributes of pork

	Site 1	Site 2	Site 3	Site 4	s.e.d.	P value
Aroma	61.5	62.7	65.3	59.6	2.6	0.542
Tenderness	56.1	56.2	53.7	53.3	2.9	0.519
Juiciness	50.7	51.3	49.6	50.2	3.5	0.512
Flavour	61.2	58.9	60.4	59.1	3.0	0.749
Overall liking	60.1	57.7	59.0	56.9	2.9	0.746
Quality grade	3.25	3.25	3.22	3.18	0.16	0.246
Re-purchase intention	3.32	3.27	3.28	3.23	0.18	0.611

4 Application of Research

4.1 Effect of sex, ageing period, cut type, cooking method and endpoint temperature on eating quality of pork

Overall, there was a clear preference for samples with higher levels of flavour, tenderness and juiciness by consumers and these were highly correlated with each other. Channon et al. (2001) also showed that overall liking of pork loin steaks and topside roasts were highly correlated, in order, with flavour (R= 0.879 and R=0.936, respectively), tenderness (R=0.866 and P=0.925, respectively) and juiciness (R=0.672 and R=0.903, respectively).

4.1.1 Sex

Juiciness, flavour, overall liking and quality grade were all influenced by sex of the pig in this study. Consumer scores for these attributes rated pork from surgical castrates higher than entire males, with females intermediate, however it is recognized that these differences were relatively small. Despite this, the fail rate for both quality grade and that for re-purchase intention was higher for pork from entire males than females and surgical castrates. Intramuscular fat levels were higher in loins from surgical castrates compared with entire males and this may have influenced consumer scores for these attributes. However, neither tenderness nor aroma was influenced by sex. As pork was evaluated for aroma on pre-cooked samples, consumers were not exposed to volatiles released during cooking and this may have removed the influence of gender on consumer scores for aroma, particularly for pork from entire males.

The findings from this study are supported by previous studies. Jeremiah et al. (1999) showed that texture of pork was not influenced by sex when entire males, females and surgical castrates were slaughtered at an average liveweight of 95.7 kg, even though higher levels of unpleasant odours and flavours were detected from pork sourced from entire males. Pauly et al. (2010) also found that tenderness did not differ between pork from entire males, surgical castrates and immunocastrates, however flavour and odour was more intense from entire males. Similarly, Font i Furnois et al. (2008), in a study comparing sensory quality of pork loin from immunocastrated males, females, surgical castrates and entire males, found that consumer acceptability of pork flavour and odour from entire males was lower than the other three sex groups. Based on these outcomes, together with results for quality grade and re-purchase intention, it is recommended that entire males should not be included as a pathway parameter to deliver consistently high quality pork to consumers. In contrast, Ngapo et al. (2012a) reported that pork from surgical castrates was more tender, reporting higher scores for flavour liking and acceptability than pork from females when assessed by Canadian consumers.

It was unfortunate that the immunocastration of male pigs in this study was not successful to allow for direct sex comparisons for eating quality attributes of pork. This will now be assessed in 3A-106 involving entire males and immunocastrates, with the same experimental design as used in this study.

4.1.2 Ageing period

Ageing for 7d improved muscle lightness of all muscles and as Australians prefer pale pork (Ngapo *et al.*, 2007), this may improve consumer acceptability of pork at the retail level. Unlike previous studies that have reported positive effects on sensory attributes of pork following ageing for 7d (Taylor *et al.*, 1995; Channon *et al.*, 2001; Channon *et al.*, 2003; Channon *et al.*, 2004) and 10-12 d post-slaughter (Taylor *et al.*, 1995; Wood *et al.*, 1996), the main effect of ageing period did not influence consumer sensory scores for any of the sensory attributes investigated in this study. Although Dransfield et al. (1980-81) showed that during the first 1-2 days post-slaughter improvements in tenderness of pork are rapid and then continue at a slower pace to then plateau at around 6 days post-slaughter, these findings suggest that ageing for 7d may not be a long enough period to consistently deliver high quality pork to consumers. A more extensive ageing period, of a time frame similar to that experienced for chilled pork (and product from other meat species) when consigned via seafreight to high value export markets, where pork is held at a controlled temperature below 0°C, without freezing, for several weeks may be required. An ageing period of 28d will be compared with 7d post slaughter and consumer assessments of pork loin steaks and silverside roasts will be conducted for female pigs as part of 3A-105. An ageing period varying from 5d to 35d, depending on the cut and grade score that is aiming to be attained, is included in the Meat Standards Australia program for beef. Ngapo et al. (2012b) reported that ageing for 43 d post-slaughter at -1.7°C only influenced sensory quality of loins when assessed by a trained panel and grilled as a steak to a endpoint temperature of 72°C or prepared as shabu shabu, but not when roasted to 72°C in a convection oven at 177°C. Grilling pork resulted in more tender pork, with a stronger sweet taste and caramel flavour when aged for 43 d compared with 5d at 3°C. However, when judged by consumers, (Ngapo *et al.*, 2012a) found that grilled pork aged for 43d was more tender, juicier, obtained higher scores for flavour liking and was more acceptable than 5d aged pork.

Although the interaction of sex x ageing period was found for juiciness, this was primarily due to lower juiciness scores for pork from entire males obtained for all of the cuts evaluated. Potential reasons for this finding are not clear.

4.1.3 Cut type, cooking method and effect of endpoint temperature

The findings from this study indicate that lowering endpoint temperature to 70°C from 75°C across all cut x cooking method combinations was either not large enough to result in significant improvements in eating quality scores, when judged by consumers, for the main effect of endpoint temperature or that different cuts from different muscles of the carcase need to be cooked differently to optimize their eating quality. In this study, sensory quality of pork sourced from the shoulder (blade and chuck tender) was higher than for loins and silversides and differences within muscles were observed due to cooking method and endpoint temperature. Positive effects of cooking to an endpoint temperature of 70°C were found for stir fry for tenderness, juiciness and overall liking as well as for steaks with respect to juiciness, flavour, overall liking, quality grade and re-purchase intention. Lowering the endpoint temperature to less than 70°C is constrained by many Australian consumers being reluctant to cook pork to a medium-rare degree degree of doneness due to the unfounded perception that undercooked Australian pork is unsafe from a food safety perspective. This issue was vigorously discussed during the development of the project methodology. It is noteworthy that the recommended minimum internal temperature for all whole cuts of meat, including pork, was revised in 2011 by USDA (http://www.fsis.usda.gov/news/NR_052411_01/index.asp) to 145°F (62.7°C) measured with a food thermometer in the thickest part of the meat, followed by a rest period of three minutes before carving or consuming. Whilst cooking pork to a endpoint temperature of 65°C has significant potential to improve pork eating quality performance, it was recognized that this would be a very difficult message to sell to result in behaviour change by consumers, at least in the short term,.

Heymann et al.(1990) reported that roasts (sourced from the shoulder (blade), loin or boneless leg containing the semimembranosus and adductor muscles) cooked to 65.6 or 71.1°C were juicier than those cooked to 76.7 or 82.2°C, but roasts cooked to 82.2°C obtained higher sensory scores than those cooked to 65.6 or 71.1°C. The lower juiciness scores were considered due to increased moisture loss at the higher cooking temperatures. In this study, cooking loss from both the loin and silverside was influenced by cooking temperature when samples were cooked in a water bath to either 70 or 75°C endpoint temperature for WB determination. Heymann et al. (1990) also found that as endpoint temperature, and moisture loss, increased, the percentage protein and lipid content of the cooked roasts also increased.

All roasts in this study were cooked with subcutaneous fat and rind left on, particularly given that this is typically how they may be prepared by consumers. It is possible that there may be differences between juiciness resulting from fat migration from subcutaneous fat remaining on the three primals evaluated as roasts, as the thickness of this fat layer will reflect differences in anatomical locations from where the cuts were obtained. In relation to findings from this study, improved juiciness of the blade roast may have been attributable to lipid migration from melted intermuscular fat. It may also be possible that flavour of roast cuts from the different primals may be influenced by variation in fatty acid composition of the different adipose depots in the animal. However, fat samples were not retained to quantify this. Interestingly, Heymann et al. (1990) also found that the fatty acid composition of cooked pork to an internal temperature of 71.1°C and higher contained more C14, C16:1, C18:1, C18:2 and C20 fatty acids than those cooked to 65.6°C. These higher levels of fatty acids in roasts cooked to higher temperatures was proposed to be due to the high level of retention and concentration of these fatty acids during cooking.

A number of studies have been conducted primarily investigating the effect of oven temperature on pork eating quality of pork roasts. Larson et al. (1992) investigated cooking pork leg roasts to 74°C in oven bags in a household-type oven to either 82, 93, 121 or 163°C and found that roasts cooked at 82 and 93°C were juicier, more tender and of better flavour compared to those cooked at higher temperatures. Jones et al. (1980) also showed that pork loins oven roasted at either 93, 121, 149 or 163°C to a endpoint temperature of 77°C were most tender when cooked at 93°C. However, juiciness was maximized by cooking at 121°C as this treatment reduced evaporation losses. In a Danish study, Aaslyng et al. (2003) roasted pork loins to an internal temperature of 68°C in ovens set at either 90 or 190°C. Juiciness was enhanced by roasting loins in an oven set at 90°C and this was considered to be due to lower cooking loss from loins compared with pork cooked in a 190°C oven.

Heymann et al. (1990) concluded that 'the optimum endpoint temperature for fresh pork roasts should be at least 71.1°C and should not exceed 76.7°C, with 71.1°C being the most desirable endpoint temperature'. Saunders et al. (1999) concluded that pork loin chops should be 'cooked to as low an endpoint as possible of 65-70°C in a moderate oven at 160°C' and the recommendation for large roasts was to 'cook to a moderately low end-point temperature of 70-75°C in a moderate to high oven (to reduce cooking times) set at 180-190°C. Baking of pork steaks is, however, not a method that is typically used by Australians.

Saunders et al.(1999) reported that juiciness and flavour were maximized at 70°C for oven roasted fillets, leg roasts, loin roasts, loin chops and scotch roasts. Siemens et al. (1990) evaluated loin chops and roasts cooked to 71.1 or 76.7°C using household type ovens set at 163°C. Overall, roasts and chops cooked to 71.1°C were preferred over those cooked to 76.7°C and lower WB shear force values were obtained when cooked to 71.1°C. In a study evaluating the effect of endpoint temperature on eating quality attributes of the pork tenderloin, Prusa and Hughes (1986) reported higher moisture losses when cooked to 77°C compared to 71°C using conventional and convection ovens set at 163°C. Prestat et al. (2002), in a study evaluating moisture enhancement, cooking method and endpoint temperature, found that grilling or frying loin chops to 80°C rather than 70°C reduced juiciness of non-enhanced chops, with flavour not influenced by endpoint temperature.

Only flavour scores of enhanced loins improved when cooked to 80°C. Grilled, non-enhanced loin chops were also juicier than fried chops. Simmons et al. (1995), in a study conducted to determine the effects of internal temperature (60, 70 or 80°C) and thickness (2.54, 1.90 and 1.27 cm) on palatability of pork loin chops cooked either on a Farberware grill or in a convection oven, found that increasing temperature reduced moisture content, juiciness and tenderness scores and increased cooking loss. Zondagh et al. (1986) also reported a decline in juiciness of pork loin roasts with increasing temperature from 77°C to 95°C in an electric oven. Although these findings concur with those of this study, it is noteworthy that all of these studies used trained sensory panelists to determine treatment effects on sensory attributes of pork rather than consumer panelists as used in this study.

Our findings suggest that roasting in an oven set at 175°C to a endpoint temperature of either 70 or 75°C does not produce a consistent quality product for all of the primals assessed in this study. The fail rate, based on quality grade score, of silverside roasts was 36%, whilst 28% of evaluations scored less than 3 for re-purchase intention. For roasts from the loin and blade, fail rates for quality score were 12.1 and 19%, respectively and those for re-purchase intention were 25% and 26%, respectively. This presents significant issues for industry, given that silversides are very commonly prepared as leg roasts. In comparison to the loin, the higher connective tissue content of the silverside is higher (Boutten *et al.*, 2000; Therkildsen *et al.*, 2002). Upon cooking, connective tissue begins to irreversibly denature and a gradual increase in collagen solubility occurs between 70 and 100°C. At temperatures above 65°C, collagen swells and softens and finally disintegrates forming gelatin (Lawrie, 1998). It can be suggested, at least for the pork silverside, that the solubility of collagen in this muscle is lower and/or overall collagen content is higher and therefore cooking to a endpoint temperature of 75°C may not be high enough to overcome collagen's contribution to overall tenderness.

Saunders et al. (1999) reported that loin chops tended to become tougher as the degree of doneness increased due to loss of moisture whilst larger, roasting cuts softened due to thermal degradation of the muscle structure, particularly connective tissue. Boles et al. (1991) also found that grilling loin steaks to an endpoint temperature of 77°C reduced both tenderness and juiciness compared with 71°C. In this study, samples presented to consumers from roasted pieces were trimmed however for both stir fry and grill, the outer surfaces remained on the piece evaluated by consumers. Consumer scores for grilled loin steaks in this study were lowest for juiciness, and these scores were reduced with increasing temperature. Overall, 30% of loin steaks evaluated by consumers were rated as either unacceptable or below average for quality and 22% of these steaks would not have been purchased again by consumers. These findings have significant relevance, given that loins are typically prepared into steaks and chops, primarily for grilling or pan frying. In relation to flavour, scores for loin steaks cooked to 75°C were lower than those cooked to 70°C. These results are in contrast to Wood et al. (1995) who found that grilling pork to an endpoint temperature of 80°C, slightly higher than that in this study, resulted in an increase in flavour intensity compared with 72.5°C.

The higher scores for tenderness, juiciness and flavour of stir fried cuts compared with roasting reflect the very short cooking time required to cook the product to the required internal temperature, maximizing juiciness and tenderness. The higher scores for pork flavour for stir fry pieces may be due to the strong correlation between tenderness, juiciness and flavour. In addition, the cooked surface remained on the stir fry samples for all cuts assessed but was removed from the roast samples prior to consumer evaluation and this may have also influenced consumer perceptions of flavour. In this study, a qualified chef supervised all cooking of the samples at each session conducted. In the home, it is suggested that there is a relatively high risk of overcooking stir fry pork pieces particularly if pork is cooked at the commencement of the preparation of a stir fried meal and remains in the pan rather than adding it to the pan once the other components have been cooked. On a cut level, stir fry samples obtained from the chuck tender located in the shoulder performed best, with an overall fail rate of 5.4%. Despite this, for reasons that are not yet understood, 24.2% of evaluations for this cut rated less than 3 for re-purchase intention.

It was not possible to identify obvious pathway parameters for consistent quality pork, other than non-inclusion of pork from entire males and cooking of pork loin steaks and stir fry pieces to a endpoint temperature of 70°C, from the results of this study. In terms of fail rates of pork:

- For the shoulder:
  - neither ageing period nor endpoint temperature had a consistent effect on reducing the fail rate of pork.
  - Ageing for 7 d increased fail rates of shoulder blade roasts from entire males, whilst fail rate was reduced for females.
  - Ageing shoulder stir fry for 7d, irrespective of cooking temperature, reduced the fail rate for product sourced from females and surgical castrates.
  - The fail rate for stir frying was lower than for roasts for the shoulder primal.
- For the loin:
  - Cooking loin steaks to an endpoint temperature of 75°C increased the fail rate compared to cooking to 70°C (reflecting lower juiciness and tenderness scores), but ageing for 7d post-slaughter did not affect this.
  - Fail rate of 7d aged loin steaks cooked to 70°C were lower across all three sexes.
  - Fail rate of 7d aged loin stir fry cooked to 70°C were lower across all three sexes
  - Fail rate of 7d aged loin roasts were similar when cooked to either 70 or 75°C for all three sexes
  - Fail rate of roasts from entire males was higher compared with females and surgical castrates.
  - Cooking loin as stir fry pieces resulted in lower fail rates than when cooked as a roast
  - *Implementation of pathway systems to maximise eating quality acceptability of loin steaks is of paramount importance given their very poor performance in this study.*
- For the silverside:
  - Fail rates of silverside roasts were comparable to those of the loin steak.
  - Ageing for 7d and cooking to 70°C did not influence fail rates of silverside stir fry from surgically castrated males.
  - For females, ageing for 7d reduced fail rates of silverside stir fry by 5%, but effect of temperature was not consistent.
  - Fail rates of silverside roasts from entire males were higher than those from females and surgically castrated males, however ageing for 7d only had a minor impact on improving its consistency.
  - *Further work is required to determine those interventions that can improve overall eating quality performance of silversides, especially but not limited to when cooked as roasts, given that leg roasts typically include the silverside primal.*

Alternative approaches are required to deliver pork products, especially roasts and steaks, that consistently meet consumer expectations once cooked. These approaches may include hanging carcases from the aitchbone, use of moisture infusion and/or lower cooking temperatures (however, this may be difficult given that roasts are generally rind-on products where consumers want to produce a good quality crackle using high temperature for a period during the cooking process). It is noteworthy that the Meat Standards Australia program for both beef and sheepmeat includes aitchbone hanging as a quality intervention as part of the eating quality pathway to improve quality consistency. For sheepmeat, aitchbone hanging can be used coupled with a temperature at pH 6 of between 8-35°C and a minimum ageing period of 5d followed by storage at 0°C. One of the pathways in the sheepmeat eating quality pathway includes a minimum ageing period of 10 d when carcases are hung from the Achilles tendon and are not electrically stimulated and storage at -1°C is required. Therefore, aitchbone hanging achieves a similar level of eating quality than ageing for a minimum period of an additional 5d.

D'Souza et al. (2012) reported that the fail rate for pork loin steaks cooked to an endpoint temperature of 75°C from immunocastrated and female pigs and supplemented with 5g magnesium bioplex/kg feed was 15%, reducing to a fail rate of 5% when pork was moisture infused. Channon et al. (2001) also showed that fail rate can be reduced to 5% by aitchbone hanging and ageing pork for 7d post-slaughter for pork loin steaks (from female pigs) cooked to 75°C, compared to a fail rate of 47% for obtained from 2d aged loin steaks obtained from Achilles hung carcases. In contrast, none of the quality interventions imposed in this study resulted in markedly large improvements in pork consistency, assessed from quality grade scores.

4.2 Effect of lecithin treatment on meat quality, carcase quality and growth performance of female pigs.

The supplementation of soy lecithin to female pigs at 5, 20 or 80 g/kg feed for 5 weeks prior to slaughter did not result in improved eating quality of pork loin steaks, as assessed by consumers. This is despite the observed effects of reduced chewiness and cohesiveness of pork, reduced expression of genes responsible for collagen synthesis as well as a reduction in hydroxyproline content of the loin of pigs fed soy lecithin. This suggests that soy lecithin may be influencing the connective tissue component of tenderness, rather than the myofibrillar lattice. However, the sensory results for tenderness concur with the WB shear force data reported by Akit et al. (2010), where no difference due to dietary lecithin was found (3.1 vs. 3.8, 3.4 and 3.3 kg, for 0, 5, 20 and 80 g/kg lecithin). Overall, pork steaks from animals in the control group obtained higher sensory scores for all attributes compared with those in the dietary lecithin treatments. Furthermore, the fail rates of pork from this study were high, despite loin steaks being cooked to an endpoint temperature of 70°C. The percentage of steaks scoring less than 3 for re-purchase intention by consumers was also very high ranging from 25%(20 g/kg) to 40% (5 g/kg).

Based purely on the findings from this study, it is not considered that the inclusion of dietary lecithin would be a feasible intervention step for inclusion in an eating quality pathway to reduce the contribution of connective tissue on tenderness and overall eating quality of pork.

4.3 Determining the effects of dietary lecithin and immunocastration on growth performance and carcase characteristics of group-housed finishing pigs.

The supplementation of 8 g/kg soy lecithin to entire male, immunocastrated male and female pigs for five weeks prior to slaughter did not result in significant improvements in pork eating quality compared to those animals that were not fed soy lecithin. These results extend those reported previously in Section 4.2 for both entire males and immunocastrates, as the previous study only included females. Interestingly, in relation to the percentage of steaks from each treatment that obtained scores of 1 and 2 for both quality grade and re-purchase intention, it was found that the fail rate for quality score was 10% lower for lecithin supplemented animals compared to control pigs. Furthermore, the fail rate of steaks from females and immunocastrated males was also considerably lower than that for entire males for both quality grade and re-purchase intention. No additional information on objective measurements or gene expression are available for further discussion in this report.

As similarly concluded in Section 4.2, the findings from this study indicated that dietary lecithin supplementation to finisher pigs would not provide the Australian pork industry with an effective tool to assist with consistent delivery of high eating quality pork to consumers. However, the improvement in actual fail rate following supplementation of soy lecithin of female and immunocastrated males is of interest and may be worthy of further exploration.

5 Conclusion

This study provided new information to assist with developing a cuts based eating quality system for Australian pork. However, the targeted fail rate of <10% for quality grade score was only achieved for shoulder stir fry, prepared from the chuck tender. Overall, sex of the pig, cut type and cooking method and the interaction with endpoint temperature were shown to be the major factors influencing the quality of pork. Although consumer scores for pork from entire males were lower for juiciness, flavour, overall liking and quality grade compared with surgical castrates, these differences were small. It was also identified that ageing for 7 d did not improve eating quality scores for pork or assist with reducing fail rates for pork in this study. Further consideration is required to determine alternative pathway interventions that could be implemented to result in consistent delivery of high quality Australian pork and fail rates of <5%.

The study also identified that greater understanding is required to determine what attributes are required for pork to be positively rated by consumers for re-purchase intention, as other than for the loin steak and silverside, where fail rates for quality grade exceeded those for re-purchase intention, all of the other cuts evaluated obtained higher fail rates for re-purchase intention than for quality grade. Work is continuing to utilize the demographic information obtained for each consumer involved in this study to determine whether this can influence quality scores obtained from consumers for fresh pork.

6 Limitations/Risks

The major limitations/risks to this work can be summarized as follows:

- It was not possible, despite the multi-factorial design of this study, to achieve fail rates of <5% for both quality grade and re-purchase intention scores. This is despite treatments used being selected based on findings from analysis of an extensive database (Channon *et al.*, 2011b) that identified positive improvements in eating quality attributes. These findings do however highlight that unlike other studies, we were not just aiming to obtain statistically significant differences in eating quality performance by imposing the various pathway interventions, we were aiming to improve its overall level of quality to result in higher scores for both quality grade and re-purchase intention (and therefore lower fail rates) when evaluated by Australian consumers.
- These findings indicate that ageing for 7d was not long enough as a minimum ageing period to result in consistent improvements in sensory quality for all cuts investigated.
- The majority of previous sensory studies with pork have been conducted using the loin primal. No published studies have been conducted with a similar experimental design over different cuts in the one study. Furthermore, cut x cooking method interactions have not been determined within the same panel, imposing a limitation on conclusions that can be made.

- It was demonstrated that the development of a cuts based eating quality for pork cannot be based primarily on the loin muscle, even if cooked in different ways, given that fail rates of different cuts cooked as roasts or stir fry were not similar.
- It was unfortunate that immunocastrated males were not included in this study as immunocastrates have not previously been included in studies of this type. Although this will be investigated as part of 3A-106 and compared with entire males, its non-inclusion in this study limits comparisons that can be made between sexes and it is noteworthy that these two studies will have been conducted one year apart.
- Based on outcomes of this study, it is suggested that the temperature difference between cooking pork to an endpoint temperature of 70C rather than 75C was not large enough to significantly affect pork eating quality due to cooking temperature alone. Although more extreme temperature conditions could have been investigated, it was determined that these endpoint temperatures were indicative of current pork consumer cooking behavior with pork (medium-well done degree of doneness) versus the endpoint temperature range that the Australian pork industry would prefer pork consumers to use in order to optimize juiciness and improve tenderness. It is known that many consumers overcook pork, to a medium-well done to well done degree of doneness. An additional issue faced by pork, unlike beef and lamb, is consumer reluctance to eat pork cooked 'with a hint of pink' ie. to a medium-rare to medium degree of doneness. There was a real risk that consumers involved in sensory panels in this study would be reluctant to eat 'undercooked' pork and/or be influenced by this when completing their sensory questionnaires. A temperature of 75°C was also used in previous Australian studies conducted as part of the industry's previous eating quality research program whilst recommendations for endpoint temperature of 70°C to optimize eating quality were made in previous APL studies (Saunders *et al.*, 2000).
- This study demonstrated that considerable effort is still required by the Australian pork industry to identify and validate additional pathway interventions that result in markedly lower fail rates on a consistent basis. Quality grade and re-purchase intention scores obtained for pork in this study, together with the percentage of evaluations that achieved scores of either 1 or 2 and referred to as 'fail rate' for quality grade and 'would not buy' for re-purchase intention showed that the Australian pork industry still has significant quality issues to overcome in order to achieve our objective of a fail rate of <5% across all cuts available to consumers.
- Soya bean lecithin was not shown to improve consumer sensory scores for pork and on this basis (despite other effects on gene expression and enzymes involved in collagen synthesis and structure and reduced chewiness and cohesiveness), cannot be recommended as an intervention step for consideration in an eating quality system.
- Demographic data and potential relationships with sensory scores, grading and re-purchase intention remain to be quantified. These will be reported to the Pork CRC as soon as practicable as an addendum to this report.

7 Recommendations

Based on the higher fail rate of pork cuts from entire males compared to females and surgical castrates, together with lower scores for juiciness, flavour, overall liking as well as lower intramuscular fat content of loins and silverside muscles, it is recommended that entire males should not be included as part of an eating quality system to deliver pork of guaranteed high eating quality to consumers.

The next phase of this work will focus on further development of eating quality system methodology, utilizing outcomes from other Pork CRC Program 3 projects, for the validation studies, to refine proposed eating quality pathways aimed at delivering consistent quality pork to consumers. This will also involve working through potential pathway interventions for various product types to allow a system to be established to allow cooking methods to be specified for cuts from eg. a female 85 kg HCW carcase to have cuts graded as 'good everyday' and what intervention steps would be needed for cuts to be graded as 'platinum pork'. -

A cuts-based system will require testing of a number of scenarios to address:

- Ageing period (and other interventions) required to shift different cuts from good, everyday to premium (use of knowledge from beef and lamb industries);
- Use of aitchbone hanging coupled with ageing period
- Recommended chilling practices – pH/temperature windows achieved and what interventions are required to overcome issues with rapid chilling
- Although much work has been conducted with electrical stimulation for lamb to allow this intervention to be included as part of the sheepmeat eating quality system, any use of electrical stimulation for pork carcases will require additional work to demonstrate that shrinkage loss is not influenced by low voltage constant current electrical stimulation.
- It is anticipated that when options are explored they will result in the Australian pork industry not being fully reliant on the use of moisture infusion as an effective mechanism to supply premium grade pork.

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