What sensory attributes are most critical for consumer evaluation within an Australian Pork eating quality program

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Executive Summary

The Australian pork industry has been working to improve the eating quality of pork over the past few decades. They have been implementing on-farm management strategies, enhancing their breeding strategies, and adopting new technologies in the production and processing sectors. However, efficient production of pork, which meets market demand for leanness, has driven genetic selection for lean growth, resulting in adverse effects on pork eating quality. Therefore, it is crucial to ascertain the meat-eating quality of commercial genetic lines to help the pork industry identify and improve its breeding strategies regarding eating quality.

Genetics can influence the physicochemical traits of muscle, which in turn affect the eating quality of pork. Connective tissue and intramuscular fat (IMF) are two key components of muscle that significantly impact the quality of meat. Connective tissue is considered to affect the "background toughness" of meat. However, some studies have shown that collagen content and solubility significantly influence meat tenderness, while others have found no effect. Similarly, IMF was reported to affect the juiciness and flavour of meat, but there were contradictory results for tenderness. A previous meta-analysis revealed that collagen content and solubility were correlated with beef sensory tenderness scores; however, the correlation coefficients varied among muscles. Thus, studies need to be undertaken to determine the contribution of connective tissue and IMF to pork eating quality under different conditions in sire and maternal pig lines.

Meat Standards Australia (MSA) has established a standard protocol for sensory evaluation of beef and lamb to ensure a consistent eating experience. However, there is no standard specifically for pork. Pork's sensory properties differ from beef and lamb, and there may be better approaches than adopting MSA for pork. Identifying the critical sensory attributes that contribute to consumer evaluation of Australian pork and determining suitable sensory evaluation methods for pork is necessary. Check-all-that-apply (CATA) is a sensory evaluation method that has been recently applied to understand the quality of processed meat. The CATA is a rapid profiling tool in which consumers are asked to select all the terms that apply to the product from a predefined list of terms. Besides CATA, biometrics are another powerful tool in the sensory evaluation of food, such as meat. Physiological responses complement self-reported sensory responses, providing a deeper understanding of consumers' unconscious emotional responses to food products. Testing whether CATA and biometrics can differentiate between line and muscle will inform the development of sensory evaluation questionnaires specific to pork.

Therefore, this study aimed to 1) compare the carcass traits, chemical properties, and eating quality of pork from different lines and muscles; 2) determine the effects of pH, collagen, and IMF on pork eating quality; and 3) find the most important sensory attributes contributing to consumer evaluation of Australian pork.

The original experiment involved the collection of *Longissimus thoracis et lumborum* (LTL) and *Semimembranosus* (SM) muscles, which were obtained from 102 pigs representing six genetic lines from a commercial abattoir (SunPork Group) for chemical and sensory analysis. However, just after sampling, the COVID-19 pandemic meant that the sensory laboratories were closed, and the extended storage meant that these samples could only be used for chemical and objective analysis, but not sensory analyses. Three years later, samples were collected from a further 78 gilts representing 7 genetic lines. These samples were analysed for chemical and objective meat quality as well as consumer sensory analyses. The sensory analysis consisted of hedonic measures of eating quality (tenderness, flavour, juiciness, and overall liking), a Check-All-That-Apply (CATA) survey where consumers choose from a list of pork-specific terms, and emotional and video recordings of the initial emotional response to odour using our specific face-reading Bio-sensory APP.

These studies found that genetic lines and muscle can impact pH, collagen characteristics, IMF and eating quality of pork. These studies confirmed that flavour was the most important sensory attribute in consumer evaluation of Australian pork, followed by tenderness. A maternal Duroc line exhibited the highest IMF content; however, consumers preferred pork from a pure terminal Large-White type line. The Landrace line received the lowest sensory scores. In the first study, IMF was positively related to objective measures of eating quality. However, relationships with sensory eating quality, while positive, were less pronounced in the second study. The small effects may be due to the low range in IMF encountered in this study, and further work is needed with a wider range in IMF. In the first objective meat quality study, total muscle collagen was positively correlated with chewiness, hardness, and shear force. However, in the second study conducted three years later, collagen characteristics had little influence on pork sensory eating quality. Nevertheless, the sensory scores for the SM were higher than those for LTL, possibly due to its higher pH and collagen solubility. The CATA method effectively differentiated between muscle and line, but the biometric approach had limited performance. Future studies can focus on breeding strategies or nutrition interventions to improve the flavour of pork.

As a result of the outcomes in these studies, the following recommendations have been made: 1/ Genetic selection should include measures of eating quality to improve the eating quality of Australian pork. These may include increasing pH, improving flavour, reducing muscle collagen and increasing IMF, 2/ Nutritional strategies to improve pork eating quality need to be investigated. These may include increasing pH, improving flavour, reducing muscle collagen and increasing IMF, 3/ On-farm and off-farm practices to reduce low pH should be employed to pork improve eating quality, 4/Characteristics of optimal pork flavour need to be determined to maximise pork eating quality, and 5/The CATA method should be incorporated in future pork sensory studies.

Table of Contents

Executive Summary ..... **i**

1. Introduction **3**

2. Methodology **4**

3. Outcomes **10**

4. Application of Research **39**

5. Conclusion **39**

6. Limitations/Risks **40**

7. Recommendations **40**

8. References **40**

Appendices **46**

1. Introduction

The Australian pork industry has been making efforts to improve the eating quality of pork over the past few decades. They have been implementing on-farm management strategies, enhancing their breeding strategies, and adopting new technologies in the production and processing sectors (Channon et al., 2017). However, efficient production of pork, which meets market demand for leanness, has driven genetic selection for lean growth, resulting in adverse effects on pork eating quality (Schwab et al., 2006). Therefore, it is crucial to survey the meat and eating quality traits of the commercial genetic lines currently in use to help the pork industry identify and improve its breeding strategies regarding eating quality.

Genetics can influence muscle physicochemical traits, which in turn affect pork eating quality. Connective tissue and intramuscular fat (IMF) are two key components of muscle that significantly impact meat quality. Connective tissue is considered to affect the "background toughness" of meat (Purslow, 2018). However, some studies have shown that collagen content and solubility significantly influence meat tenderness, while others have found no effect (Ngapo et al., 2002; Rhee et al., 2004; Roy et al., 2021). Similarly, IMF was reported to affect the juiciness and flavour of meat (Czarniecka-Skubina et al., 2010; Fortin et al., 2005), but there were contradictory results for tenderness (Channon, D'Souza, & Dunshea, 2018; Gondret et al., 2006). A previous meta-analysis revealed that collagen content and solubility were correlated with beef sensory tenderness scores; however, the correlation coefficients varied among muscles (Li et al., 2022a). Also, there were few studies on pork; therefore, it was not possible to conduct a similar meta-analysis for pork. Thus, more studies need to be undertaken to determine the contribution of connective tissue and IMF to pork eating quality under different conditions.

In Australia, Meat Standards Australia (MSA) has established a standard protocol for sensory evaluation of beef and lamb to consistently measure the eating experience (Watson et al., 2008). However, there is no standard specifically for pork. Pork's sensory properties differ from beef and lamb, and there may be better approaches than adopting MSA for pork (Channon, D'Souza, Jarrett, et al., 2018). Identifying the critical sensory attributes that contribute to consumer evaluation of Australian pork and determining suitable sensory evaluation methods for pork is necessary. Check-all-that-apply (CATA) is a sensory evaluation method that has been recently applied to understand the quality of processed meat (Torrico et al., 2018). The CATA is a rapid profiling tool in which consumers are asked to select all the terms that apply to the product from a predefined list of terms (Oliver et al., 2018). Besides CATA, biometrics are another powerful tool in the sensory evaluation of food, such as meat (Fuentes et al., 2018; Mena et al., 2023; Torrico et al., 2018). Physiological responses complement self-reported sensory responses, providing a deeper understanding of consumers' unconscious emotional responses to food products. Testing whether CATA and biometrics can differentiate between line and muscle will inform the development of sensory evaluation questionnaires specific to Australian pork.

Therefore, this study aimed to 1) compare the carcass traits, chemical properties, and eating quality of pork from different lines and muscles; 2) determine the effects of pH, collagen characteristics, and IMF on pork eating quality; and 3) find the most important sensory attributes contributing to consumer evaluation of Australian pork. It is hypothesized

that: 1) lines from the Duroc breed will have higher IMF content and will be preferred by consumers; 2) the *Longissimus thoracis et lumborum* (LTL) will show similar pH, lower collagen content, and higher sensory scores than the *Semimembranosus* (SM); 3) collagen solubility and IMF content will be positively related to sensory attributes, while collagen content will be negatively related to sensory attributes; 4) biometrics and CATA can differentiate between lines and muscles; 5) flavour will be the most important sensory attribute contributing to overall liking..

2. Methodology

Preface

Pork samples were collected in early 2020, but the closure of the sensory laboratory and the inability to have consumers on campus during the COVID-19 lockdown seriously delayed the project. Additionally, the extended frozen storage of pork products was deemed an unacceptable risk to sensory attributes and possibly to food safety; therefore, it was decided that these samples couldn't be consumed when the sensory laboratory reopened in March 2022. However, these samples were used to conduct the chemical analyses, and these results have been reported as Experiment 1. In a previous progress report, we stated that we would collect samples in late June or early July 2022, when a gap in Sunpork's ability to supply pork could be identified. However, due to pressing commercial needs, perhaps tied in with the Japanese Encephalitis Virus, this gap didn't eventuate. Consequently, these samples were not collected until March 2023, and these form the basis of Experiment 2.

Experiment 1

Animals, experimental design, housing

One hundred and two female pigs from six genetic lines were used: PM-LR – Pure maternal, Landrace-type (n = 18, five sires); PM-LW – Pure maternal, Large White-type (n = 18, five sires); PM-D – Pure maternal, Duroc-type (n = 18, six sires); SynT-LWLR – Synthetic terminal, large white and Landrace-type (n = 12, five sires); PT-D – Pure terminal, Duroc-type (n = 18, five sires); and PT-LW – Pure terminal, Large White-type (n = 18, seven sires). Live weights of the pigs were measured before slaughter. All pigs were slaughtered under normal commercial conditions in a commercial abattoir (SunPork Group, Kingaroy, QLD Australia) on three days in February with the same number of animals in each line on the same day. Individual hot carcass weights (Trim 1, Anonymous, 2016) were measured and fat depth at P2 site was determined via ultrasound (AutoFOM, Frontmatec Group, Kolding, Denmark). At 24h postmortem, the pH of LTL between the 12th and 13th rib was measured using a portable pH/temperature meter (TPS WP-80M, Brendale, QLD, Australia). pH meter was calibrated using pH 4.01, 7.01 and 10.01 buffer at the abattoir environment, and the temperature was also recorded. Cold carcass weights (Trim 21, Anonymous, 2016) were determined by abattoir staff. Dressing percentage was calculated using individual hot and carcass weights, and cold weights were reported. LTL and *Semimembranosus* (SM) were excised from the loin and leg primal, respectively, of each carcass. Each primal was trimmed of visible fat and connective tissue before being cut in half, vacuum packed and frozen. Frozen samples were transported to the University of Melbourne under an Animal Ethics Committee scavenged tissue licence (Ethics ID #22011). Because of restrictions related to Covid lockdowns the samples were stored frozen (-20^{o}C) for 18 months before analysis.

Sample preparation

Twelve LTL and twelve SM from each line were selected for meat quality analysis. Meat samples were cut frozen using a meat and bone bench band saw (CARNIVORE equipment, Melbourne, Australia). A cube of 110 ± 10.0 g was removed from each sample, vacuum packed and kept frozen for texture analysis. Triplicates of 25g meat pieces were placed in 50ml flat bottom Falcon tubes and freeze-dried for 72h, prior to collagen and IMF analyses. Weights of all samples and tubes were recorded for the calculation of water content. All samples were kept frozen at -20ºC before analysis.

Objective meat quality

Pork samples for texture analysis were cooked in vacuum-packed bags from frozen in a circulating water bath (JULABO GmbH, Seelbach, Germany) at 75 °C until the internal temperature reached 70 °C. Internal temperature was monitored using a thermocouple. Samples were randomly assigned to be cooked in 7 batches. After cooking, the samples were cooled in an ice-water bath for 30 min and then stored in a cold room at 2 °C overnight. On the next day, meat samples were taken out from the packaging and excess moisture was absorbed before the weights were recorded.

For Warner-Bratzler shear force (WBSF) measurement, pork samples were cut into cuboids with a cross-section of 10 mm x 10 mm along the muscle fibre direction. They were sheared with a V-shape blade using the Lloyd Texture Analyser TA2 (AMETEK, Berwyn, Pennsylvania USA). The analyser was equipped with a 500 N load cell and the extension rate was 300 mm/min. Six replicates were measured for each sample. Texture profile analysis (TPA) was obtained using the Lloyd Texture Analyser TA2 (AMETEK, Berwyn, Pennsylvania USA) fitted with a cylindrical probe with a diameter of 6 mm. The sample was cut to a thickness of 10 mm. Texture profile was obtained with a double bite process and the sample was compressed to 80% of its height. The test speed was 50 mm/min and the wait time was 0.1 s. Five measurements were taken on each sample. Hardness (N), cohesiveness, adhesiveness (Nmm), chewiness (N), resilience and springiness were obtained from the NEXYGENPlus program (AMETEK, Berwyn, Pennsylvania USA).

Chemical analyses

Total and soluble collagen content were determined using the AOAC method 990.26 (Kolar, 1990) for quantification of hydroxyproline as described by Starkey et al. (2015) with some modifications. Pork samples were freeze-dried for three days and then powdered using a knife. Water content was calculated using the weights before and after freeze-drying. A triplicate of 0.2 g freeze-dried powder was hydrolysed in 3.5 M H_2SO_4 for 16 h at 105 °C. For soluble collagen, 1.0 g of powder was added to 10 mL of water and heated in a water bath at 80 °C for 2 h, with vortexing every 30 min. A standard curve was plotted using a hydroxyproline solution with concentrations of 0, 1.2, 2.4, 3.6, 4.8 and 6.0 µg/ml in H_2O. A conversion factor of 7.25 was used to convert hydroxyproline content to collagen content. The total collagen content was expressed in milligrams per gram of fresh meat. Collagen solubility was expressed as the percentage of soluble collagen divided by total collagen content.

Intramuscular fat (IMF) content was determined using the AOAC method 991.36 (AOAC, 1995) with some modifications. Briefly, triplicate of 3.5 g freeze-dried samples were powdered and wrapped in a folded Watman no.1 filter paper. Each sample was placed in a Soxhlet apparatus using diethyl ether as extraction solvent. Intramuscular fat content was expressed as percent fat of fresh meat weight (w/w).

Statistical analyses

The carcass traits were analysed using analysis of variance (ANOVA) in GenStat (16th Edition, VSN International) with genetic line as a treatment factor. Cooking loss and texture data were analysed using Restricted Maximum Likelihood (REML) with line, muscle, and their interaction as fixed effects. Kill day and cooking day were random effects. Collagen characteristics and IMF were analysed using Restricted Maximum Likelihood (REML) with genetic line and muscle as well as their interactions as treatment factors and kill day as a random factor. Comparison between line types (maternal vs terminal) was also performed. Multiple comparison was performed with Fisher's protected LSD. Principal component analysis (PCA) was performed in RStudio (RStudio, PBC) on both LTL and SM, as well as on individual muscles, and the results were visualised with a PCA loading plot. Generalised linear models were performed to analyse the effects of collagen characteristics and IMF on pork texture in GenStat (16th Edition, VSN International). The models are as follows:

Model 1: y = intercept + collagen content + collagen solubility + IMF + muscle + line

Where y = adhesiveness, chewiness, cohesiveness, cooking loss, hardness, resilience, springiness or WBSF. Cooking day and kill day were random factors.

Model 2: y = intercept + collagen content + collagen solubility + IMF + line

Where y = chewiness, hardness or WBSF. Cooking day and kill day were random factors. It's performed on the data of single muscle.

Model 3: y = intercept + collagen content + collagen solubility + IMF + muscle

Where y = chewiness or WBSF. Cooking day and kill day were random factors. It's performed on the data of single genetic line.

Experiment 2

Animals, experimental design, housing

Seventy-eight female pigs from seven genetic lines were used (information on the genetic company was proprietary): PM-LR – Pure maternal, Landrace-type (n = 12, 7 sires); PM-LW – Pure maternal, Large White-type (n = 12, 4 sires); PM-D – Pure maternal, Duroc-type (n = 12, 6 sires); PT-D – Pure terminal, Duroc-type (n = 11, 7 sires); PT-LW – Pure terminal, Large White-type (n = 12, 7 sires); PT-LR - Pure Terminal, Landrace-type (n = 6, 4 sires); Comp-P×LW×D - Composite Terminal – Pietran × Large white × Duroc (n = 13, 8 sires). Line type was defined as a maternal or terminal line. All pigs were raised on a large commercial piggery. They were fed *ad libitum* to commercial pelleted diets. They were housed indoors with slatted floors. Pigs were slaughtered at 22 weeks of age. The live weight of the pigs was measured before slaughter. All pigs were slaughtered under normal commercial conditions in a commercial abattoir for two days (SunPork Group, Kingaroy, QLD Australia), and the measurement of carcass traits (hot carcass weight, cold carcass weight, P2 fat depth, and the dressing percentage) followed the method described previously (Li et al., 2024). At 24h post-mortem, *Longissimus thoracis et lumborum* (LTL) and *Semimembranosus* (SM) were excised from the loin and leg primal of each carcass. Individual muscles were vacuum packed and frozen at 48h post-mortem and transported to the University of

Melbourne under an Animal Ethics Committee scavenged tissue license (Ethics ID #22011). The samples were stored frozen (-18 °C) until analysis.

Sample preparation
Meat samples were cut from frozen using a hand-held saw. For LTL, a 13.5 cm long block was cut from the center of the muscle for sensory evaluation. One 60 g-sample was cut from the anterior part of the muscle adjacent to the sensory evaluation sample for freeze-drying. For the SM, the muscle was cut in half (across the skin); the lateral part was used for sensory evaluation, and the medial part was used to remove a 60 g sample for freeze-drying. The location of the sample on each muscle for sensory evaluation was fixed. Samples for sensory evaluation were vacuum-packed and kept frozen until analysis. Small pieces for freeze-drying were placed in sample jars and freeze-dried for 120 h for collagen and intramuscular fat (IMF) analyses. Weights of all samples and jars were recorded to calculate water content. All samples were kept frozen before analysis.

Chemical analysis
Intramuscular fat content was determined by AOAC method 991.36 (AOAC, 1995) with some modifications (Li et al., 2022b). Briefly, freeze-dried samples were powdered with a coffee blender. Duplicates of 3.5 g of meat powder were wrapped in No.1 Whatman filter paper and subjected to Soxhlet extraction. The extraction solvent was diethyl ether. IMF content was calculated gravimetrically and expressed as a percentage of fresh meat.

Collagen content and solubility were determined using a colorimetric AOAC method 990.26 (Kolar, 1990) to determine hydroxyproline content as described by Li et al. (2022). Total and soluble collagen content were calculated with a conversion factor of 7.25. Collagen content was expressed as mg/g fresh meat, and collagen solubility was expressed as the percentage of soluble collagen divided by total collagen content.

Sensory evaluation
Sensory evaluation was conducted in the sensory research facility at the University of Melbourne. This project has been approved by The University of Melbourne Human Ethics Committee (Ethics ID: 21857). A total of 229 consumers were recruited at the University of Melbourne by putting up posters, and posting on online notice boards and the School newsletters. There was a maximum of 18 consumers per sensory evaluation session, and the sensory evaluation sessions were conducted over four days with three or four sessions daily. One session lasted for approximately 45 min.

All consumers attended a briefing session before they started the evaluation. At the briefing, they confirmed that they were all above the age of 18, had consumed pork in the past three months, were willing to consume pork, consented to video recording, did not have strong-tasting food or coffee one hour before the test, and did not wear strong perfume. During the briefing session, consumers also filled out the demographic questionnaire (see supplementary material); the demographics of consumers are shown in Appendix 1. Participants' ages ranged from 18 to above 70 years old. A majority of participants were Asian and around two-third of them were female. The demographics represented the population of young people living in the urban area and also the student population. The participants were also informed that they could withdraw anytime, and their responses would be kept confidential.

All participating consumers sign a consent form before sensory evaluation commenced. They confirmed their informed consent by signing, "I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep". Upon completion of the briefing, consumers were directed to individual sensory booths. Each consumer was given a fork, napkin, and a cup of 10% apple juice (apple juice : water 1:9) and crackers to cleanse their palate between samples. Each consumer was served seven samples. The first serving was the "Link" sample (the first sample all consumers tasted, results not recorded) so they could familiarize themselves with the questionnaire. Consumers answered the questionnaire on the tablet using the Bio-Sensory application (App: The University of Melbourne, Parkville, VIC, Australia) (Fuentes et al., 2018). This App was set to record videos while consumers evaluated samples to get their initial reaction, when they assessed liking of odour. The videos were 10-30 s long.

The LTL from a previous project was selected as the "Link" sample, which consisted of a commercial product from the same company, aged two days and frozen for ten months. Samples for sensory evaluation were thawed at 2°C for 24h. The thawed muscle sample was cut perpendicular to the muscle fiber direction into three steaks of 2.5 cm thickness, which were then further cut into sensory samples of 5.0 × 5.0 × 2.5 cm^3. All samples were free of subcutaneous fat and connective tissue. After fabrication of the sensory samples, the pH and temperature of the remaining muscle were measured with a portable pH/temperature meter (TPS WP-80, TPS, Brendale QLD, Australia) equipped with an electrode (model TPS-121234, TPS, Brendale QLD, Australia). The pH meter was calibrated with pH 4.01 and 7.01 buffers. All steaks were randomized across sessions within a day. After cutting, six sensory samples for one round were placed on laminated A4 paper with their sample ID and random number code. Steaks and the A4 paper were 50% vacuum packed (50% of air taken out) and stored at 2°C overnight before cooking. The next day, steaks for the same session were transported to the kitchen in a Styrofoam box 10 min before the session started. The clamshell grill (Silex S-Tronic Single Grill, Silex, Marrickville NSW, Australia) was turned on two hours before the session began to pre-heat, and the temperature was set at 160 °C on both sides. The steaks were cooked to an internal temperature of 70 °C and rested for 30s. After resting, the final internal temperature of the steaks was around 72 °C. A set of starter samples was cooked to determine the cooking time with a thermocouple inserted in one steak. The cooking time was from 4 min 45 s to 5 min. After resting, steaks were cut into four pieces, from which three pieces were randomly chosen to be served to consumers in plastic sauce containers (70 ml, Genfac Plastics, Melbourne VIC, Australia). The fourth piece was discarded. All sauce containers were covered with aluminum foil to maintain the aroma. Each muscle was served to nine consumers, and each consumer tasted six samples, excluding the "Link".

The questionnaire consisted of three parts. In the first part, consumers assessed sensory attributes on hedonic scales from 0 to 100. The scale was 15 cm long and the results were converted to 100-point basis. The wording on the two extremes of the scale was: Liking of appearance – 0 (dislike extremely) and 100 (like extremely); liking of odour – 0 (dislike extremely) and 100 (like extremely); tenderness – 0 (not tender) and 100 (very tender); juiciness – 0 (not juicy) and 100 (very juicy); liking of flavour – 0 (dislike extremely) and 100 (like extremely); overall liking – 0 (dislike extremely) and 100 (like extremely).

In the second part, consumers answered whether they detected any off-flavour ("Yes" or

"No") and their purchase intent (1 – "I would definitely not buy it", 2 – "I would probably not buy it", 3 – "I might buy it", 4 – "I would probably buy it" or 5 – "I would definitely buy it"). Success was defined as consumers selecting 4 and 5. They were also asked to assess the quality grading of the sample on a hedonic scale with the following phrases marked on the scale: "Unsatisfactory", "Good everyday", "Better than good everyday" and "Premium".

The third part was check-all-that-apply (CATA), where consumers selected all the words that best described the sample. There were 32 CATA terms, including 11 odour terms "fecal odour", "sweet odour", "roasted odour", "oily odour", "mushroom odour", "metallic odour", "earthy odour", "sour odour", "fruity odour", "familiar odour", and "porky odour"; 15 flavour terms "mushroom flavour", "buttery flavour", "clean flavour", "earthy flavour", "fecal flavour", "familiar flavour", "fatty flavour", "metallic flavour", "porky flavour", "roasted flavour", "sweet taste", "sour taste", "fruity flavour", "savory flavour" and "flavourless"; and six texture terms "chewy", "dry", "fibrous", "juicy", "soft" and "tender". These terms were determined with modifications Silva et al. (2023). Due to the maximum number of options to display in the App for CATA questions, odour and texture terms were displayed on one page, flavour terms were on another page, and all terms were in a fixed order.

Statistical analysis

Carcass traits and chemical data were analyzed using a linear mixed model restricted maximum likelihood (REML) generalized linear mixed model in GenStat (22nd edition, VSN International, UK). For carcass traits, the fixed factor = line or line type, and the random factor = kill day. Two LTL samples with extremely high pH values (pH > 6.80) were eliminated from chemical and sensory data analysis. For chemical data (pH, IMF, collagen content, and solubility), the fixed model = line (line type) + muscle + line (line type) × muscle, and the random model = kill day.

The sensory evaluation results were analyzed using R (R Core Team, 2021) in RStudio (Posit, PBC, Boston, US). The line scale questions were analyzed using a linear mixed-effects model with packages "lme4", "jtools" and "emmeans". The fixed model = muscle + line + muscle × line, and the random model = carcass + participant + session. The predicted means, standard errors of the mean, and *P* values were recorded. The probability of regular (no off-flavour), the propability of success in purchase intent, and CATA data were analyzed by a generalized linear mixed-effects model with logarithmic transformation for the probability and binomial distribution. The fixed model = muscle + line + muscle × line, and the random model = carcass + participant + session. CATA data was also visualized using correspondence analysis (CA) using the "FactoMineR" and "factoextra" packages in RStudio. The CATA terms which had cumulative contribution less than 3.60 to Factor 1 and 2 were excluded from analysis. A linear mixed-effects model analyzed the predictions of overall liking, probability of success (purchase intent), and quality grading from individual sensory attributes (liking of flavour, tenderness, juiciness, odour, and appearance). The fixed model = liking of appearance + liking of odour + tenderness + juiciness + liking of flavour, and the random model = carcass + participant + session + muscle + line. The prediction of sensory attributes with chemical measurements was analyzed using the same method, and the fixed model = pH + IMF + collagen content + collagen solubility + muscle + line + muscle × line. A penalty-lift analysis was conducted on individual CATA terms to analyze the difference in the overall liking of a CATA term versus when it was not selected. The result of the penalty-lift analysis was visualized using a bar plot.

Facial expression data was analyzed according to the method described by Gonzalez Viejo et al. (2023). Videos were recorded and screened manually for data quality to ensure they showed the whole face of the participants. Selected videos were then translated to emotion responses using an automated software developed by the Digital Agriculture, Food and Wine Sciences Group from The University of Melbourne based on the histogram-oriented gradient and support vector machine algorithms from the Affectiva software development kit (SDK; Affectiva, Boston, MA, USA). The variables obtained from this software were described by Gupta et al. (2022). Variables chosen for analysis were joy, relaxed, anger, rage, sadness, smirk, contempt, and valence because they best described emotions and contributed significantly to variations. Emotion variables were visualized by principal component analysis (PCA) in RStudio using packages "FactoMineR" and "factoextra".

3. Outcomes

3.1 Results

Experiment 1

Carcasses from the six lines differed in dressing percentage (P = 0.025) and fat depth at P2 site (P<0.001) at a similar live weight (Table 1). Line PT-D showed a lower dressing percentage (76.0%) than line PM-LR, PM-LW, SynT-LWLR and PT-LW. P2 fat depth was the highest in line PM-LW (13.2 mm) followed by line PM-D (11.1 mm) and PM-LR (10.9 mm). Line SynT-LWLR, PT-D and PT-LW had lower P2 fat depth than the other three lines (9.31, 9.32 and 9.17 mm, respectively). The terminal lines had higher P2 fat depth than maternal lines (Table 2). The lines did not differ in liveweight, cold carcass weight or pH at 24h post-mortem.

Cooking loss differed between sire lines (P < 0.001) (Table 3). However, there was a close to significant muscle × line interaction (P = 0.050) such that within the LTL, pork from line PT-D had the highest cooking loss (19.0%) and it was higher than that of line SynT-LWLR (16.3%) and PM-LW (16.2%), whereas, within the SM, line PT-LW showed the highest cooking loss (18.2%), while the lowest loss occurred in line PM-LW (15.3%) and PM-D (15.0%). Overall, the cooking loss of lines was in the order: PT-LW > PT-D > PM-LR > SynT-LWLR > PM-D > PM-LW (P <0.001). The terminal lines had higher cooking loss than the maternal lines (Table 4).

The LTL exhibited higher WBSF than the SM (P = 0.018, Table 3). However, the SM showed higher adhesiveness (P = 0.008), chewiness (P = 0.011) and springiness (P <0.001) than LTL. Genetic lines affected hardness (P = 0.032) and cohesiveness (P = 0.023). Line SynT-LWLR showed the highest hardness (37.1 N) and cohesiveness (0.453) among the six lines. Pork from the terminal lines also exhibited higher chewiness and hardness than maternal line (Table 4).

The SM had higher collagen (P <0.001) and IMF content (P <0.001) and lower collagen solubility (P <0.001) than LTL. Collagen and IMF content differed between lines (P = 0.036 and 0.003, respectively). Pork from line PT-LW had the highest collagen content (6.28 mg/g fresh meat) and it was significantly higher than line PT-D (5.65 mg/g fresh meat) and line SynT-LWLR (5.47 mg/g fresh meat). Pork from line SynT-LWLR showed lower IMF content (1.08%) than all other lines. For the maternal and terminal lines, pork from maternal lines

had higher IMF content than pork from terminal lines (1.77 vs 1.53%) and the difference was close to significance (P = 0.099, Table 4).

Figure 1 is the PCA loading plot for all variables across pooled muscles. PC1 explained 30.3% of the variations and it was represented (contributions >0.50) by chewiness, hardness, resilience, cohesiveness and adhesiveness, in descending order. PC2 explained 20.3% of variations and it was explained by springiness, IMF and WBSF (contributions >0.50).

In the PCA loading plot of LTL, PC1 explained 36.6% of variation and PC2 explained 15.1% of variation (Figure 2a). Chewiness, hardness, resilience, WBSF, cohesiveness, adhesiveness and cooking loss contributed to PC1, while IMF, springiness and collagen content contributed to PC2 (contribution >0.50). On the other hand, the PCA loading plot of SM showed that PC1 and PC2 collectively explained 43.0% of variations (Figure 2b). PC1 was explained by chewiness, hardness, resilience and cohesiveness (contribution >0.50). PC2 was explained by adhesiveness, cooking loss, cohesiveness, springiness and collagen solubility (contribution >0.50).

In all samples, collagen content was positively related to adhesiveness (slope = 0.77 ± 0.31, P = 0.013), chewiness (slope = 0.41 ± 0.172, P = 0.019), hardness (slope = 0.95 ± 0.383, P = 0.015) (Table 6). For WBSF, the contribution of collagen content was positive (slope = 1.54 ± 0.654, P = 0.020) and the effect of IMF was negative (slope = -2.18 ± 0.910, P = 0.018). The SM had lower WBSF than the LTL when adjusted for collagen content and IMF (slope = -3.77 ± 1.79, P = 0.037).

Within LTL, collagen content was positively related to chewiness (slope = 0.69 ± 0.263, P = 0.011), hardness (slope = 1.56 ± 0.602, P = 0.012) and WBSF (slope = 3.25 ± 1.16, P = 0.007). IMF was negatively related to WBSF (slope = -6.75 ± 2.47, P = 0.008). However, the slopes of collagen content and IMF were insignificant in the SM (Table 7).

The effects of collagen content and IMF on chewiness and WBSF were mostly insignificant in individual genetic line (Table 8). The only significant relationship was found in line PT-D where collagen content was positively related to chewiness (slope = 1.36 ± 0.384, P = 0.002).

Table 1. Carcass traits of six different lines (PM-LR, PM-LW, PM-D, SynT-LWLR, PT-D and PT-LW)

	Line[1]						Significance	
	PM-LR	PM-LW	PM-D	SynT-LWLR	PT-D	PT-LW	sed	*P* -value
n	18	18	18	12	18	18		
Liveweight (kg)	101.1	97.3	99.9	95.8	99.1	100.3	2.31	0.25
Hot dressing percentage (%)	77.2[a]	77.4[a]	76.4[ab]	77.4[a]	76.0[b]	77.3[a]	0.54	0.025
Cold carcass weight (kg)	70.6	68.3	69.1	67.5	68.3	71.0	1.59	0.21
P2 fat depth (mm)	10.9[b]	13.2[a]	11.1[b]	9.31[c]	9.32[c]	9.17[c]	0.66	<0.001
pH_{24}[2]	5.64	5.65	5.64	5.68	5.63	5.70	0.032	0.16

[a, b, c] Data with different superscripts differed significantly.

[1] PM-LR – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; SynT-LWLR – Synthetic terminal, Large white and Landrace-type; PT-D – Pure terminal, Duroc-type; and PT-LW – Pure terminal, Large White-type).

[2] pH was measured at *Longissimus thoracis et lumborum* (LTL) between 12th and 13th ri pH was measured at *Longissimus thoracis et lumborum* (LTL) between 12th and 13th ribs

Table 2. Carcass traits of maternal (n = 54) and terminal line (n = 48)

	Maternal	Terminal	sed	*P*-value
Live weight (kg)	99.4	98.7	1.41	0.61
Cold weight (kg)	69.4	69.1	0.96	0.79
Dressing percentage (%)	77.0	76.9	0.33	0.67
P2 fat depth (mm)	11.8	9.26	0.407	<0.001
pH_{24}[1]	5.64	5.67	0.029	0.41

[1] pH was measured at *Longissimus thoracis et lumborum* (LTL) between 12th and 13th ribs.

Table 3. Cooking loss, Warner Bratzler shear force (WBSF) and texture profile analysis of two pork muscles (*Longissimus thoracis et lumborum*, LTL and *Semimembranosus*, SM) or six genetics lines (PM-LR, PM-LW, PM-D, SynT-LWLR, PT-D and PT-LW)

	Muscle			Line[1]							Significance		
	LTL	SM	s.e.d.[2]	PM-LR	PM-LW	PM-D	SynT-LWLR	PT-D	PT-LW	s.e.d.[2]	Muscle	Line	Muscle x line
n	72	72		24	24	24	24	24	24				
Cooking loss (%)	17.6	16.3	0.62	16.8^{bc}	15.8^{c}	16.4^{c}	16.7^{bc}	17.8^{ab}	18.4^{a}	0.59	0.129	**<0.001**	0.050
WBSF (N)	35.0^{x}	30.9^{y}	1.46	33.5	30.1	34.4	35.7	33.6	30.3	2.17	**0.018**	0.057	0.68
Hardness (N)	34.1	35.7	0.74	34.8^{abc}	33.2^{c}	34.0^{bc}	37.1^{a}	36.0^{ab}	34.1^{bc}	1.29	0.074	**0.032**	0.25
Cohesiveness	0.440	0.444	0.0055	0.448^{a}	0.425^{b}	0.443^{a}	0.453^{a}	0.440^{ab}	0.441^{ab}	0.0081	0.43	**0.023**	0.33
Adhesiveness (Nmm)	9.54^{y}	11.7^{x}	0.643	10.4	11.6	9.28	10.5	11.4	10.5	1.042	**0.008**	0.28	0.32
Chewiness (N)	11.4^{y}	12.7^{x}	0.37	12.2	11.3	11.6	12.9	12.3	12.0	0.58	**0.011**	0.081	0.30
Resilience	0.438	0.439	0.0077	0.445	0.426	0.436	0.448	0.438	0.437	0.0083	0.96	0.12	0.90
Springiness	0.760^{y}	0.800^{x}	0.0066	0.779	0.795	0.767	0.768	0.776	0.798	0.0129	**<0.001**	0.073	0.14

$^{x, y}$ Data with different superscripts differed significantly between muscles. $^{a, b, c}$ Data with different superscripts differed significantly between lines.

[1] PM-LR – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; SynT-LWLR – Synthetic terminal, Large white and Landrace-type; PT-D – Pure terminal, Duroc-type; and PT-LW – Pure terminal, Large White-type).

[2]s.e.d. = Standard error of differences of means

Table 4. Cooking loss, texture of pork and Intramuscular fat (IMF) and collagen characteristics of pork (*Longissimus thoracis et lumborum* and *Semimembranosus*) from maternal (n = 54) and terminal line (n = 48)

	Maternal	Terminal	sed	*P*-value
Cooking loss (%)	16.1	17.2	0.36	0.002
Adhesiveness (Nmm)	10.4	11.0	0.62	0.28
Chewiness (N)	11.7	12.4	0.34	0.037
Cohesiveness	0.439	0.445	0.0049	0.25
Hardness (N)	34.0	35.7	0.77	0.027
Resilience	0.435	0.440	0.0048	0.28
Springiness	0.778	0.781	0.0080	0.68
WBSF (N)	32.8	32.8	1.33	0.99
IMF (%)	1.76	1.52	0.124	0.052
Collagen content (mg/g meat)	5.90	5.80	0.170	0.54
Collagen solubility (%)	9.19	8.86	0.551	0.53

Table 5. Collagen characteristics and intramuscular fat content of two pork muscles (*Longissimus thoracis et lumborum*, LTL and *Semimembranosus*, SM) from six genetics lines (PM-LR, PM-LW, PM-D, SynT-LWLR, PT-D and PT-LW)

	Muscle			Line[1]							Significance		
	LTL	SM	s.e.d.[2]	PM-LR	PM-LW	PM-D	SynT-LWLR	PT-D	PT-LW	s.e.d.[2]	Muscle	Line	Muscle x line
n	72	72		24	24	24	24	24	24				
Collagen content (mg/g fresh meat)	5.25^{y}	6.48^{x}	0.167	5.82^{abc}	5.73^{bc}	6.18^{ab}	5.47^{c}	5.67^{bc}	6.31^{a}	0.290	**<0.001**	**0.036**	0.99
Collagen solubility (%)	10.6^{x}	7.77^{y}	0.537	8.95	9.93	9.10	8.01	9.31	9.71	0.932	**<0.001**	0.40	0.39
Intramuscular fat content (%)	1.19^{y}	2.10^{x}	0.120	1.69^{a}	1.74^{a}	1.87^{a}	1.08^{b}	1.67^{a}	1.82^{a}	0.207	**<0.001**	**0.003**	0.58

$^{x, y}$ Data with different superscripts differed significantly between muscles. $^{a, b, c}$ Data with different superscripts differed significantly between lines.

[1] PM-LR – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; SynT-LWLR – Synthetic terminal, Large white and Landrace-type; PT-D – Pure terminal, Duroc-type; and PT-LW – Pure terminal, Large White-type).

[2]s.e.d. = Standard error of differences of means

Table 6. Muscle traits which significantly affected cooking loss or texture of pork (regression coefficients, standard errors and *P*-value).

Traits	Coefficient[1]	Standard error	*P*-value
Adhesiveness (Nmm)			
Intercept	4.82	2.04	0.020
Collagen content (mg/g)	0.77	0.308	0.013
Chewiness (N)			
Intercept	10.0	1.14	<0.001
Collagen content (mg/g)	0.41	0.172	0.019
Hardness (N)			
Intercept	30.9	2.53	<0.001
Collagen content (mg/g)	0.95	0.383	0.015
WBSF (N)[2]			
Intercept	30.0	4.33	<0.001
Collagen content (mg/g)	1.54	0.654	0.020
IMF (%)[3]	-2.18	0.910	0.018
Muscle (SM)[4]	-3.77	1.79	0.037

[1] Models are y = intercept + collagen content + collagen solubility + IMF + muscle + line. y = adhesiveness, chewiness, cohesiveness, cooking loss, hardness, resilience, springiness or WBSF.
[2] WBSF = Warner-Bratzler shear force
[3] IMF = intramuscular fat
[4] SM = *Semimembranosus*. The coefficient is the difference compared to *Longissimus thoracis et lumborum* (LTL).

Table 7. Regression coefficients (slope) and *P*-value of texture parameters against muscle traits in different muscles (*Longissimus thoracis et lumborum*, LTL and *Semimembranosus*, SM)

		Chewiness (N)[1]		Hardness (N)		WBSF (N)[2]	
	Muscle	Slope[3]	*P*-value	Slope	*P*-value	Slope	*P*-value
Collagen content (mg/g)	LTL	0.69 ± 0.263	**0.011**	1.56 ± 0.602	**0.012**	3.25 ± 1.16	**0.007**
	SM	0.14 ± 0.239	0.560	0.26 ± 0.512	0.612	0.058 ± 0.664	0.931
IMF (%)[4]	LTL	-0.64 ± 0.558	0.253	-1.93 ± 1.28	0.136	-6.75 ± 2.47	**0.008**
	SM	-0.028 ± 0.276	0.920	-0.48 ± 0.591	0.417	-0.27 ± 0.766	0.721

[1] Models are y = intercept + collagen content + collagen solubility + IMF + line. y = chewiness, hardness or WBSF.
[2] WBSF = Warner-Bratzler shear force
[3] Slope is expressed as mean ± standard error.
[4] IMF = intramuscular fat

Table 8. Regression coefficients and *P*-value of texture parameters against muscle traits in different lines

		Chewiness (N)[1]		WBSF (N)[2]	
	Line	Slope[3]	*P*-value	Slope	*P*-value
Collagen content (mg/g)	PM-LR	0.63 ± 0.679	0.364	-0.54 ± 2.09	0.799
	PM-LW	0.65 ± 0.361	0.090	1.18 ± 1.74	0.503
	PM-D	0.25 ± 0.407	0.543	1.11 ± 1.36	0.425
	SynT-LWLR	0.34 ± 0.492	0.502	3.09 ± 2.48	0.227
	PT-D	1.36 ± 0.384	**0.002**	0.95 ± 1.63	0.567
	PT-LW	-0.14 ± 0.407	0.737	2.00 ± 1.58	0.220
IMF (%)[4]	PM-LR	-0.39 ± 0.626	0.546	-1.79 ± 1.93	0.365
	PM-LW	-0.58 ±0.434	0.199	0.29 ± 2.09	0.890
	PM-D	1.35 ± 1.08	0.227	-0.47 ± 3.61	0.897
	SynT-LWLR	0.26 ± 1.07	0.811	-9.70 ± 5.40	0.088
	PT-D	0.28 ± 0.409	0.503	-1.21 ± 1.74	0.494
	PT-LW	-0.13 ± 0.587	0.826	-1.94 ± 2.27	0.403

[1] Models are y = intercept + collagen content + collagen solubility + IMF + muscle. y = chewiness, hardness or WBSF.
[2] WBSF = Warner-Bratzler shear force
[3] Slope is expressed as mean ± standard error.
[4] IMF = intramuscular fat

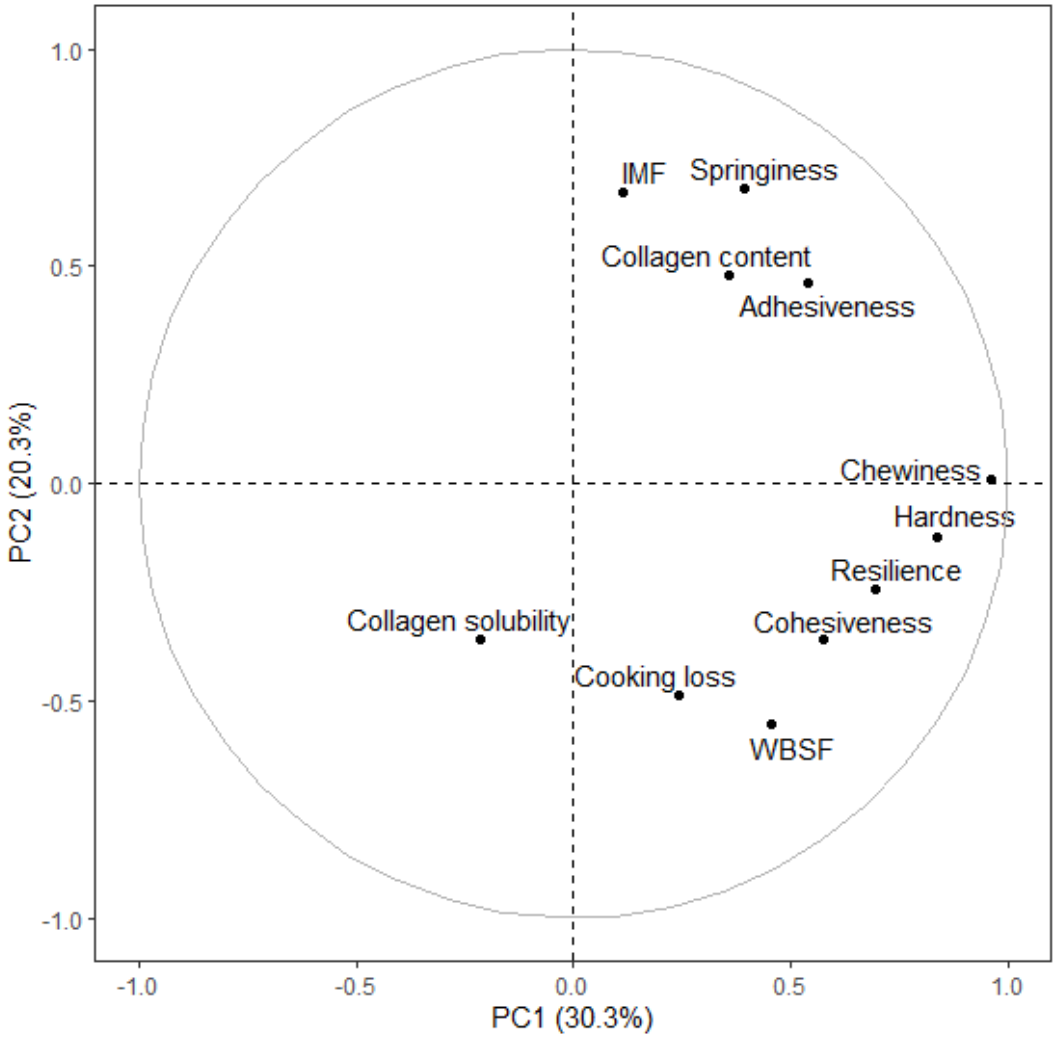
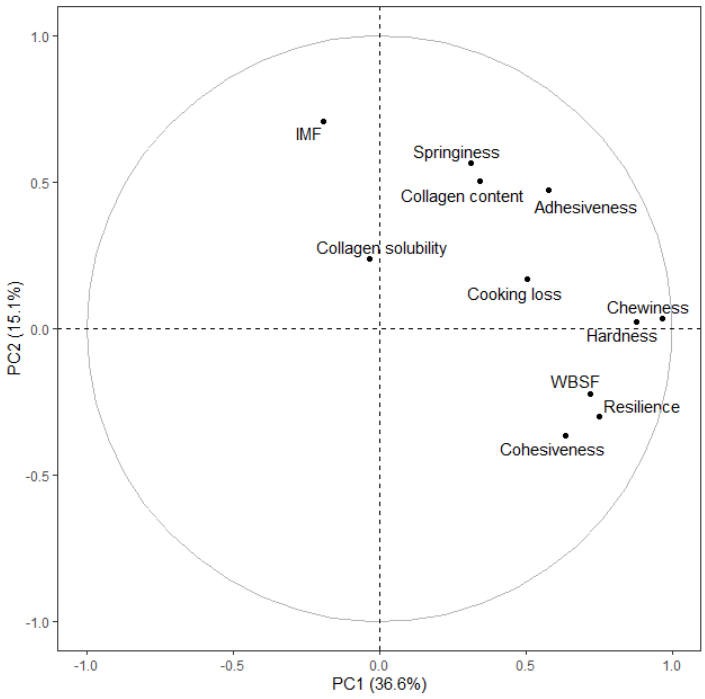


Figure 1. Principal component analysis (PCA) loading plot of meat quality attributes. IMF = intramuscular fat content, WBSF = Warner-Bratzler shear force.

(a)



(b)

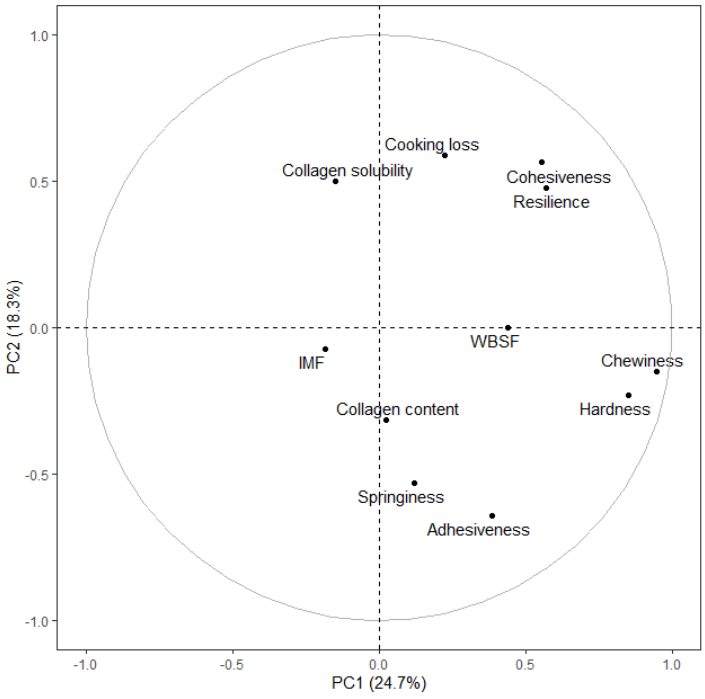


Figure 2. Principal component analysis (PCA) loading plot of meat quality attributes of (a) *Longissimus thoracis et lumborum*, LTL and (b) *Semimembranosus*, SM. IMF = intramuscular fat content, WBSF = Warner-Bratzler shear force.

Experiment 2

Carcass traits and chemical properties differed between lines. Line PT-D had the highest IMF content (0.959%), while lines from the Landrace breed had the lowest IMF content (PM-LR = 0.667% and PT-LR = 0.650%, $P = 0.004$, Table 9). However, P2 fat depth was the highest in line PM-LW and lowest in line PT-D (Supplementary Table 10). Also, the maternal line showed higher P2 fat depth than the terminal line (Table 11), but they did not differ in chemical properties (Table 12).

Muscles differed in pH and collagen solubility (Table 9). The SM showed higher pH (5.70 vs 5.64, $P < 0.001$) and higher collagen solubility than the LTL (13.0 vs 9.90%, $P < 0.001$). There was no difference in IMF or collagen content between muscles.

For the sensory evaluation results (Table 13), line PT-LW showed the highest tenderness score, while line PT-LR showed the lowest (59.6 vs 45.4, $P = 0.005$). The liking of flavour score was also the highest in samples from line PT-LW, with the lowest score in line PM-LR (60.8 vs 54.1, $P = 0.039$). A similar trend was observed for the probability of success for purchase intent (0.361 vs 0.205, $P = 0.005$) and quality grading (44.5 vs 36.9, $P = 0.041$).

The LTL exhibited higher scores in liking of appearance (65.9 vs 62.9, $P = 0.001$) (Table 13) and odour (66.1 vs 64.0, $P = 0.019$) and probability of no off-flavour than the SM (0.986 vs 0.975, $P = 0.016$). The SM showed higher scores in tenderness (58.4 vs 48.7, $P < 0.001$), juiciness (62.3 vs 54.1, $P < 0.001$), liking of flavour (59.9 vs 56.0, $P < 0.001$), and overall liking (60.3 vs 54.0, $P < 0.001$). The SM also showed a higher probability of success for purchase intent (0.353 vs 0.214, $P < 0.001$) and higher quality grading than LTL (44.0 vs 36.8, $P < 0.001$).

In terms of interactions, LTL from line Comp-P×LW×D showed higher scores in liking of appearance than SM from line PM-D, PT-D, and Comp-P×LW×D (Table 2). Within the LTL, pork from line Comp-P×LW×D showed higher tenderness than those from lines PM-LW and PT-LR. Line PT-LW received the highest tenderness score within the SM, while line PT-LR received the lowest. Similarly, the SM from line PT-LW showed the highest probability of success for purchase intent, while LTL from line PT-LR showed the lowest.

The LTL was perceived as chewy, dry, and flavourless for the CATA results. The SM was tender, soft, juicy, and rich in porky odour, fatty flavour, porky flavour, and metallic flavour (Table 14). From the CA, Factor 1 explained 38.5% variations and the most contributing variable was tender, while Factor 2 explained 23.9% variations and the most contributing variable was sour odour (Figure 3). Seven lines fell into four origin sections. Line PT-LR was flavourless with an oily odour. Line PM-LR and Comp-P×LW×D were chewy and fibrous. Line PT-D had a fatty flavour, while line PM-D was tender, soft and had a sweet odour. Line PT-LW and PM-LW were juicy and sweet.

Figures 4 and 5 are PCA biplots of emotions. PC 1 explained 34.6% of variations, while PC2 explained 26.9% of variations. PC1 was mostly contributed by positive emotions valence, joy and relaxed. PC2 was mostly contributed by negative emotions anger, rage and sadness. All the positive emotions were on the right side and negative emotions were on the left. Individual sample points scattered along joy and relaxed or anger, rage, sadness, smirk and contempt. The mean points of the seven lines clustered around the origin and had no difference in emotions. Similarly, there was no difference between muscles in consumers' emotional responses.

Table 15 shows the contribution of chemical properties to sensory attributes. pH positively contributed to tenderness, juiciness, and overall liking. The slope of juiciness for IMF was close to significant ($P = 0.066$). Collagen content and collagen solubility did not significantly affect sensory attributes.

Table 16 shows the prediction of overall liking, probability of success (purchase intent) and quality grading using individual sensory attributes. The prediction equation for overall liking was:

$$\text{Overall liking} = 0.65\ (\pm 0.02)\text{flavour} + 0.23\ (\pm 0.01)\ \text{tenderness} + 0.10\ (\pm 0.02)\ \text{juiciness} + 0.08\ (\pm 0.02)\ \text{appearance}$$

The prediction equation for the probability of success in purchase intent was:

$$\text{Probability of success (purchase intent)} = 0.11\ (\pm 0.01)\ \text{flavour} + 0.04\ (\pm 0.01)\ \text{tenderness} + 0.03\ (\pm 0.01)\ \text{juiciness}$$

The prediction equation for quality grading was:

$$\text{Quality grading} = 0.53\ (\pm 0.02)\ \text{flavour} + 0.24\ (\pm 0.02)\ \text{tenderness} + 0.11\ (\pm 0.02)\ \text{juiciness} + 0.10\ (\pm 0.02)\ \text{odour} + 0.05\ (\pm 0.02)\ \text{appearance}$$

Figure 6 shows the results of the penalty-lift analysis. The top five drivers for positive overall liking scores were “tender”, “soft”, “juicy”, “buttery flavour” and “sweet taste”. The top five CATA terms which negatively affected overall liking scores were “dry”, “flavourless”, “metallic odour”, “fecal flavour” and “fecal odour”.

Table 9. The effect of line (L), muscle (M) and the interaction of line and muscle (L×M) on the chemical properties of pork

	Muscle[1]	Line[2]							SED[3]	*P*-value[4]		
		PM-LR	PM-LW	PM-D	PT-D	PT-LW	PT-LR	Comp-P×LW×D		L	M	L × M
N	LTL	12	12	12	11	12	6	11				
	SM	12	12	12	11	12	6	13				
pH	LTL	5.62	5.60	5.67	5.67	5.59	5.67	5.66	0.034	0.063	**<0.001**	0.50
	SM	5.69	5.71	5.69	5.70	5.66	5.73	5.70				
IMF (%)[5]	LTL	0.558	0.794	0.894	0.920	0.798	0.666	0.927	0.1309	**0.004**	0.33	0.46
	SM	0.776	0.928	1.02	0.836	0.707	0.634	0.915				
Collagen content (mg/g)	LTL	4.07	4.45	4.13	4.37	4.61	4.25	4.16	0.300	0.32	0.15	0.17
	SM	4.31	4.52	4.53	4.64	4.26	3.81	4.77				
Collagen solubility (%)	LTL	9.96	11.0	10.3	9.94	9.11	9.74	9.29	1.063	0.058	**<0.001**	0.23
	SM	12.9	12.5	14.1	12.2	12.3	15.6	11.7				

[1] LTL = *Longissimus thoracis et lumborum*, SM = *Semimembranosus*

[2] PM-LR – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; PT-D – Pure terminal, Duroc-type; PT-LW – Pure terminal, Large White-type; PT-LR - Pure Terminal, Landrace-type; Comp-P×LW×D - Composite Terminal – Pietran × Large white × Duroc.

[3] SED = average standard error of difference of the interaction

[4] Data was analyzed by generalized linear mixed-effect model in GenStat. Fixed factors = line + muscle + line × muscle; Random factor = kill day. Data is expressed as mean ± standard error of mean. L = line, M = muscle, L × M = line and muscle interaction.

[5] IMF = intramuscular fat

Table 10. Carcass traits of different lines

	Line[1]							P-value[2]
	PM-L	PM-LW	PM-D	PT-D	PT-LW	PT-L	Comp-P×LW×D	
N	12	12	12	11	12	6	13	
Live weight (kg)	99.7 ± 4.0	99.2 ± 4.0	101 ± 4.0	100 ± 4.0	103 ± 4.0	100 ± 4.1	101 ± 4.0	0.23
Cold weight (kg)	70.4^{bc} ± 1.84	69.5^{c} ± 1.84	69.9^{c} ± 1.84	71.9^{abc} ± 1.86	72.7^{ab} ± 1.84	69.1^{c} ± 2.02	74.0^{a} ± 1.82	**<0.001**
Dressing percentage (%)	77.6^{bc} ± 1.00	76.4^{cde} ± 1.00	76.0^{de} ± 1.00	78.2^{ab} ± 1.01	77.2^{bcd} ± 1.00	75.5^{e} ± 1.10	79.4^{a} ± 0.99	**<0.001**
P2 fat depth (mm)	9.22^{c} ± 0.553	11.3^{a} ± 0.553	10.6^{ab} ± 0.553	8.83^{c} ± 0.571	9.48^{bc} ± 0.553	9.60^{bc} ± 0.725	9.22^{c} ± 0.538	**0.006**

[1] PM-L – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; PT-D – Pure terminal, Duroc-type; PT-LW – Pure terminal, Large White-type; PT-L - Pure Terminal, Landrace-type; Comp-P×LW×D - Composite Terminal – Pietran × Large white × Duroc.
[2] Data was analyzed by generalized linear mixed-effect model in GenStat. Fixed factors = line; Random factor = kill day. Data is expressed as mean ± standard error of mean.
[a, b, c, d, e] Data with different superscripts differ significantly between lines

Table 11. Carcass traits of maternal and terminal line

	Line type		P-value[1]
	Maternal	Terminal	
N	36	42	
Live weight (kg)	99.8 ± 3.9	101.3 ± 3.9	0.059
Cold weight (kg)	69.9[b] ± 1.69	72.4[a] ± 1.68	**<0.001**
Dressing percentage (%)	76.7[b] ± 0.95	77.9[a] ± 0.94	**0.005**
P2 fat depth (mm)	10.4[a] ± 0.41	9.25[b] ± 0.393	**0.005**

[1] Data was analyzed by generalized linear mixed-effect model in GenStat. Fixed factors = line type; Random factor = kill day. Data is expressed as mean ± standard error of mean.
[a, b] Data with different superscripts differ significantly between line types

Table 12. Chemical properties of maternal and terminal line

	Muscle[1]	Line type		P-value[2]		
		Maternal	Terminal	Line type	Muscle	Line type × muscle
N	LTL	36	40			
	SM	36	42			
pH	LTL	5.63 ± 0.048	5.64 ± 0.048	0.76	**<0.001**	0.46
	SM	5.70 ± 0.048	5.69 ± 0.048			
IMF (%)	LTL	0.749^{b} ± 0.0576	0.847^{ab} ± 0.0552	0.85	0.35	**0.035**
	SM	0.910^{a} ± 0.0576	0.795^{ab} ± 0.0542			
Collagen content (mg/g)	LTL	4.22 ± 0.148	4.37 ± 0.144	0.51	0.16	0.51
	SM	4.45 ± 0.148	4.45 ± 0.142			
Collagen solubility (%)	LTL	10.4 ± 0.86	9.48 ± 0.85	0.053	**<0.001**	0.72
	SM	13.2 ± 0.86	12.5 ± 0.85			

[1] LTL = *Longissimus thoracis et lumborum*, SM = *Semimembranosus*

[2] Data was analyzed by generalized linear mixed-effect model in GenStat. Fixed factors = line type + muscle + line type × muscle; Random factor = kill day. Data is expressed as mean ± standard error of mean.

[a, b] Data with different superscripts differ significantly between line types × muscle

Table 13. The effect of line (L), muscle (M) and the interaction of line and muscle (L×M) on the sensory attributes of pork

	Muscle[1]	Line[2]							SED[3]	P-value[4]		
		PM-LR	PM-LW	PM-D	PT-D	PT-LW	PT-LR	Comp-P×LW×D		L	M	L × M
N	LTL	104	104	106	99	107	54	95				
	SM	107	103	105	97	105	54	116				
Liking of appearance	LTL	63.7^{ab}	64.4^{ab}	63.7^{ab}	67.8^{ab}	66.1^{ab}	65.3^{ab}	69.9^{a}	2.54	0.17	**0.001**	**0.027**
	SM	62.3^{ab}	64.7^{ab}	60.7^{b}	59.9^{b}	67.1^{ab}	64.3^{ab}	61.4^{b}				
Liking of odour	LTL	62.9	65.2	64.9	68.0	66.8	68.6	66.0	2.46	0.23	**0.019**	0.79
	SM	62.1	63.7	64.7	63.1	66.0	65.6	62.8				
Tenderness	LTL	47.2^{cd}	43.5^{d}	51.9^{bcd}	52.4^{bcd}	50.4^{bcd}	40.8^{d}	54.7^{bc}	4.26	**0.005**	**<0.001**	**0.036**
	SM	56.4^{abcd}	56.4^{abc}	59.4^{abc}	55.5^{abc}	68.7^{a}	50.0^{bcd}	62.4^{ab}				
Juiciness	LTL	56.0	52.2	57.1	52.1	52.9	52.9	55.6	3.51	0.43	**<0.001**	0.92
	SM	62.6	62.0	66.0	59.3	63.9	59.4	63.1				
Liking of flavour	LTL	52.8	55.8	56.2	57.5	58.3	51.7	59.6	2.98	**0.039**	**<0.001**	0.51
	SM	55.4	61.3	60.4	57.6	63.3	60.0	61.3				
Overall liking	LTL	52.0	51.9	56.1	58.3	55.0	48.0	56.7	3.39	0.076	**<0.001**	0.16
	SM	56.6	61.5	60.6	58.9	65.8	56.6	62.2				
Probability of no off-flavour	LTL	0.983	0.974	0.974	0.998	0.989	0.974	0.988	0.0224	0.075	**0.016**	0.37
	SM	0.948	0.983	0.965	0.982	0.982	0.965	0.983				
Probability of success (purchase intent)[5]	LTL	0.182^{c}	0.151^{c}	0.281^{abc}	0.295^{abc}	0.229^{bc}	0.148^{c}	0.373^{abc}	0.0840	**0.005**	**<0.001**	**0.010**
	SM	0.244^{bc}	0.359^{abc}	0.477^{ab}	0.240^{b}	0.525^{a}	0.302^{abc}	0.387^{abc}				
Quality grading[6]	LTL	33.6	35.0	39.4	39.5	38.6	32.4	39.2	3.30	**0.041**	**<0.001**	0.16
	SM	40.2	43.9	45.7	40.7	50.4	42.2	45.2				

[1] LTL = *Longissimus thoracis et lumborum*, SM = *Semimembranosus*

[2]PM-LR – Pure maternal, Landrace-type; PM-LW – Pure maternal, Large White-type; PM-D – Pure maternal, Duroc-type; PT-D – Pure terminal, Duroc-type; PT-LW – Pure terminal, Large White-type; PT-LR - Pure Terminal, Landrace-type; Comp-P×LW×D - Composite Terminal – Pietran × Large white × Duroc.

[3] SED = average standard error of difference

[4] Data was analyzed by generalized linear mixed-effect model in RStudio. Fixed factors = line + muscle + line × muscle; Random factor = participant + carcass + session. Data is expressed as mean ± standard error of mean. Line scale ranged from 0 to 100.

[5] Success = participants selected 4 (I would probably buy it) and 5 (I would definitely buy it).
[6] Quality grading was on a line scale labeled unsatisfactory, good everyday, better than good everyday and premium at fixed intervals.
[a, b,c,d] Data with different superscripts differ significantly ($P < 0.05$) between line and muscles.

Table 14. Probability of selected (mean ± standard error of mean) check-all-that-apply (CATA) terms of *Longissimus thoracis et lumborum* (LTL) and *Semimembranosus* (SM)

	Muscle		*P*-value[1]
	LTL	SM	Muscle
Tender	0.216^{y} ± 0.0295	0.388^{x} ± 0.0382	**<0.001**
Chewy	0.591^{x} ± 0.0278	0.520^{y} ± 0.0283	**0.022**
Dry	0.318^{x} ± 0.0259	0.167^{y} ± 0.0091	**<0.001**
Soft	0.117^{y} ± 0.0207	0.230^{x} ± 0.0304	**<0.001**
Juicy	0.332^{y} ± 0.0250	0.458^{x} ± 0.0267	**<0.001**
Porky odour	0.432^{y} ± 0.0389	0.521^{x} ± 0.0393	**0.010**
Fatty flavour	0.0060^{y} ± 0.00431	0.0112^{x} ± 0.00750	**0.020**
Flavourless	0.108^{x} ± 0.0186	0.0582^{y} ± 0.0120	**<0.001**
Porky flavour	0.467^{y} ± 0.0392	0.609^{x} ± 0.0375	**<0.001**
Sour taste	0.110^{x} ± 0.0248	0.0707^{y} ± 0.0177	**0.006**
Metallic flavour	0.0300^{y} ± 0.0091	0.0544^{x} ± 0.0145	**0.003**
Fibrous	0.345 ± 0.0319	0.308 ± 0.0302	0.22
Sweet odour	0.0500 ± 0.0120	0.0579 ± 0.0131	0.46
Roasted odour	0.343 ± 0.0348	0.291 ± 0.0322	0.080
Oily odour	0.0014 ± 0.0012	0.0020 ± 0.0017	0.15
Earthy odour	0.0323 ± 0.0093	0.0353 ± 0.0010	0.68
Sour odour	0.0443 ± 0.0121	0.0492 ± 0.0130	0.63
Fruity odour	0.0001 ± 0.1165	0.0007 ± 0.0004	0.99
Familiar odour	0.155 ± 0.0252	0.162 ± 0.0257	0.76
Roasted flavour	0.310 ± 0.0346	0.328 ± 0.0354	0.56
Earthy flavour	0.0395 ± 0.0116	0.0315 ± 0.0097	0.26
Fruity flavour	0.0016 ± 0.0016	0.0013 ± 0.0014	0.61
Mushroom flavour	0.0001 ± 0.0001	0.0002 ± 0.0002	0.60
Clean flavour	0.226 ± 0.0261	0.222 ± 0.0256	0.87
Familiar flavour	0.160 ± 0.0236	0.185 ± 0.0257	0.30
Savory flavour	0.137 ± 0.0241	0.140 ± 0.0245	0.91

[1] Data was analyzed by generalized linear mixed-effect model in RStudio. Fixed factors = line + muscle + line × muscle; Random factor = participant + carcass + session. Data is expressed as mean ± standard error of mean.

[x, y] Data with different superscripts differ significantly ($P < 0.05$) between muscles.

Table 15. Slopes (mean ± standard error of mean) and *P*-values of sensory attributes vs chemical measurements

	Tenderness		Juiciness		Liking of flavour		Overall liking	
	Slope[1]	*P*-value	Slope	*P*-value	Slope	*P*-value	Slope	*P*-value
pH	28.1 ± 10.86	**0.010**	25.1 ± 8.89	**0.005**	7.59 ± 7.68	0.32	17.1 ± 8.59	**0.048**
IMF (%)[2]	2.92 ± 3.03	0.34	4.54 ± 2.45	0.066	3.09 ± 2.10	0.14	3.46 ± 2.37	0.15
Collagen content (mg/g)	-0.72 ± 1.26	0.57	-0.49 ± 1.04	0.64	1.25 ± 0.91	0.17	1.82 ± 1.01	0.071
Collagen solubility (%)	-0.01 ± 0.33	0.98	-0.04 ± 0.27	0.89	0.19 ± 0.24	0.43	0.14 ± 0.27	0.59

[1] Data was analyzed by generalized linear mixed-effect model in RStudio. Fixed factors = line + muscle + pH + IMF + collagen content + collagen solubility; Random factor = participant + carcass + session+ line + muscle

[2] IMF = intramuscular fat

Table 16. Slopes (mean ± standard error of mean) and P-values of overall liking and quality grading vs individual sensory attributes

	Liking of appearance		Liking of odour		Tenderness		Juiciness		Liking of flavour	
	Slope[1]	*P*-value	Slope	*P*-value	Slope	*P*-value	Slope	*P*-value	Slope	*P*-value
Overall liking	0.08 ± 0.02	**<0.001**	0.01 ± 0.02	0.74	0.23 ± 0.01	**<0.001**	0.10 ± 0.02	**<0.001**	0.65 ± 0.02	**<0.001**
Probability of success (purchase intent)[2]	0.01 ± 0.01	0.43	0.01 ± 0.01	0.10	0.04 ± 0.01	**<0.001**	0.03 ± 0.01	**<0.001**	0.11 ± 0.01	**<0.001**
Quality grading[3]	0.05 ± 0.02	**0.029**	0.10 ± 0.02	**<0.001**	0.24 ± 0.02	**<0.001**	0.11 ± 0.02	**<0.001**	0.53 ± 0.02	**<0.001**

[1] Data was analyzed by generalized linear mixed-effect model in RStudio. Fixed factors = appearance + odour + tenderness + juiciness + liking of flavour; Random factor = participant + carcass + session+ line + muscle

[2] Success = participants selected 4 (I would probably buy it) and 5 (I would definitely buy it).

[3] Quality grading was on a line scale labeled unsatisfactory, good everyday, better than good everyday and premium at fixed intervals.

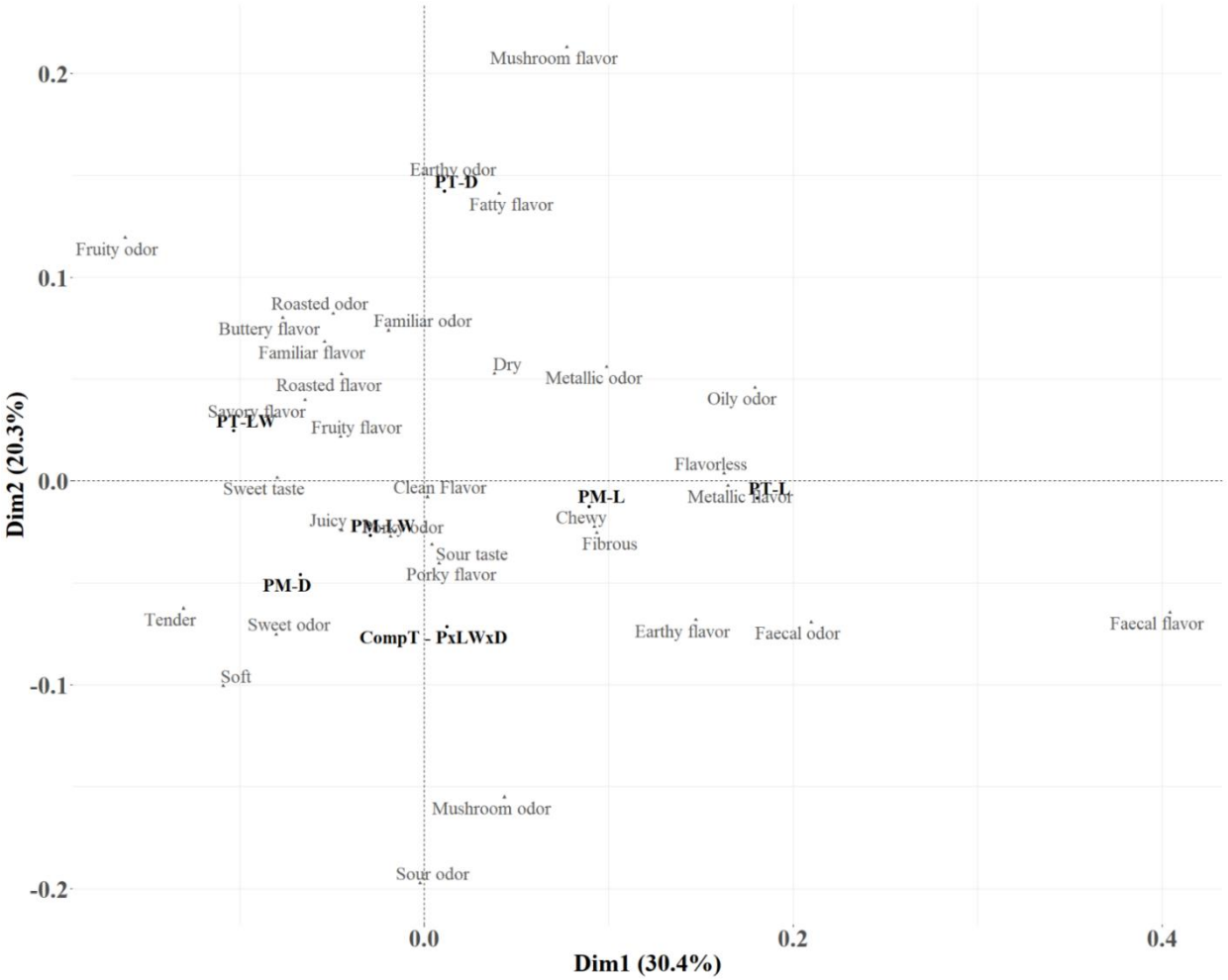


Figure 3. Correspondence analysis biplot of check-all-that-apply result on different lines without outliers. A – Pure maternal, Landrace-type; B – Pure maternal, Large White-type; C – Pure maternal, Duroc-type; E – Pure terminal, Duroc-type; F – Pure terminal, Large White-type; G - Pure Terminal, Landrace-type; H - Composite Terminal – Pietran x Large white x Duroc.

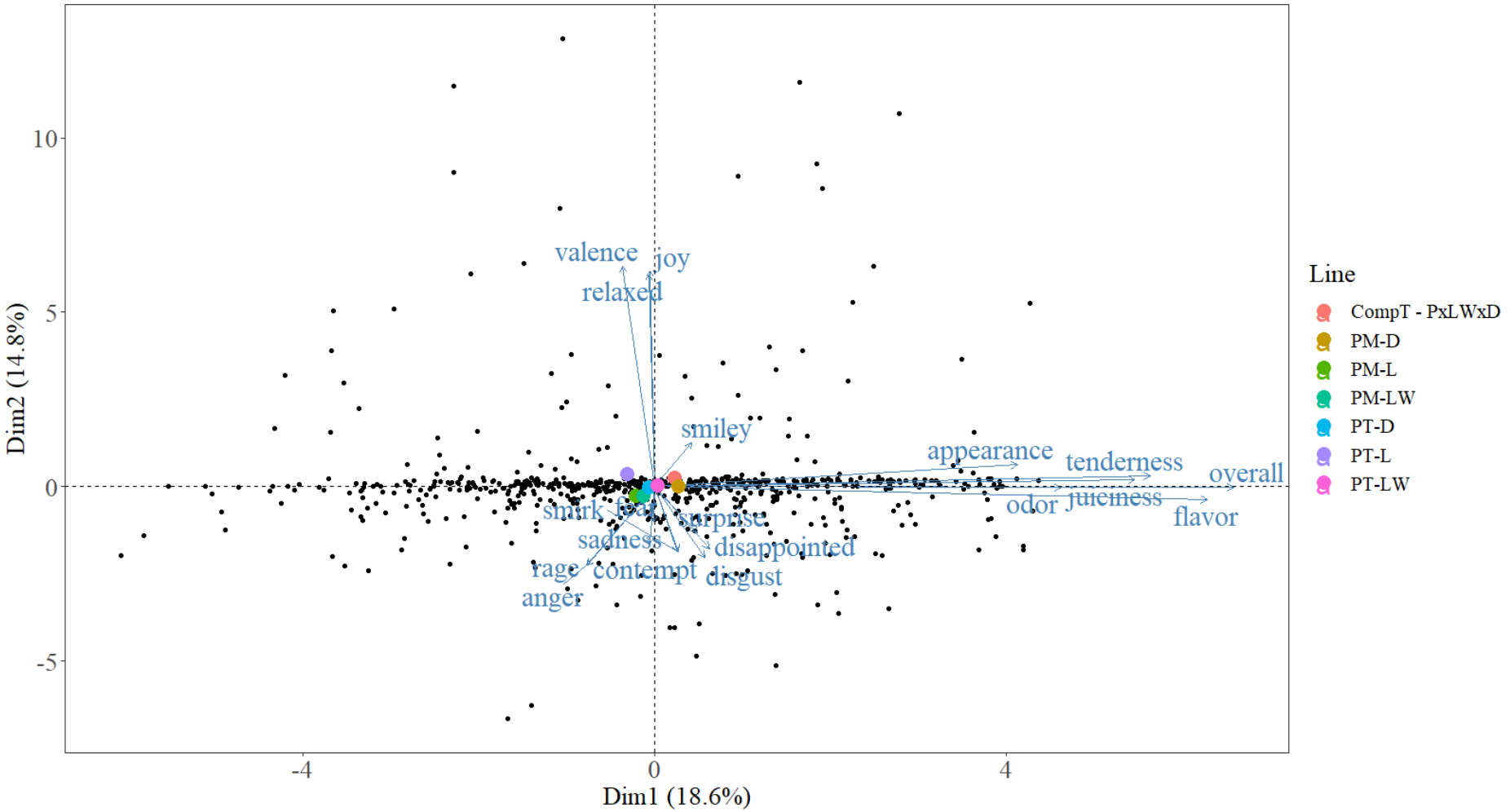


Figure 4. Principle component analysis biplot of sensory attributes and emotion of seven lines

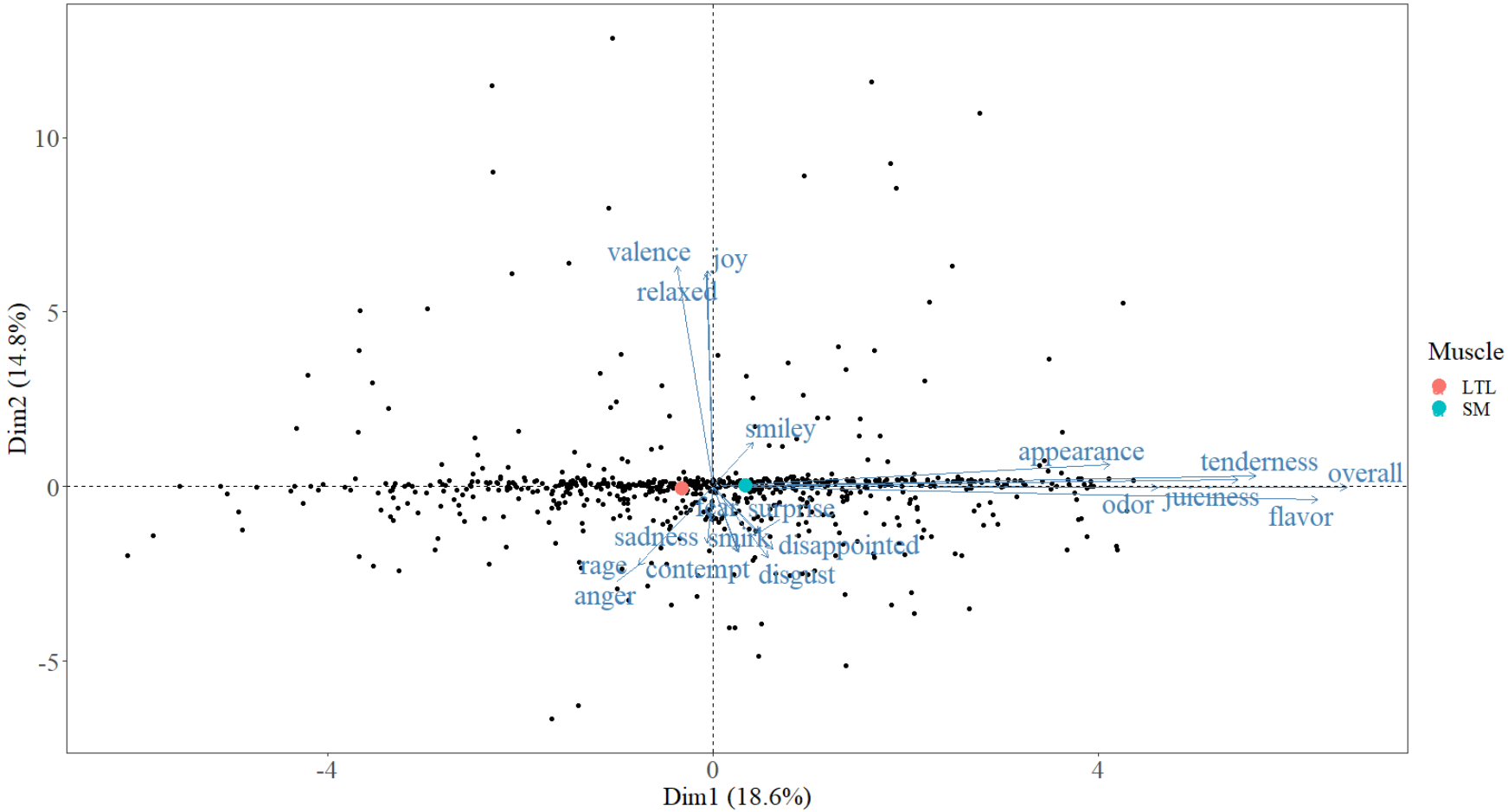


Figure 5. Principle component analysis biplot of sensory attributes and emotion of two muscles

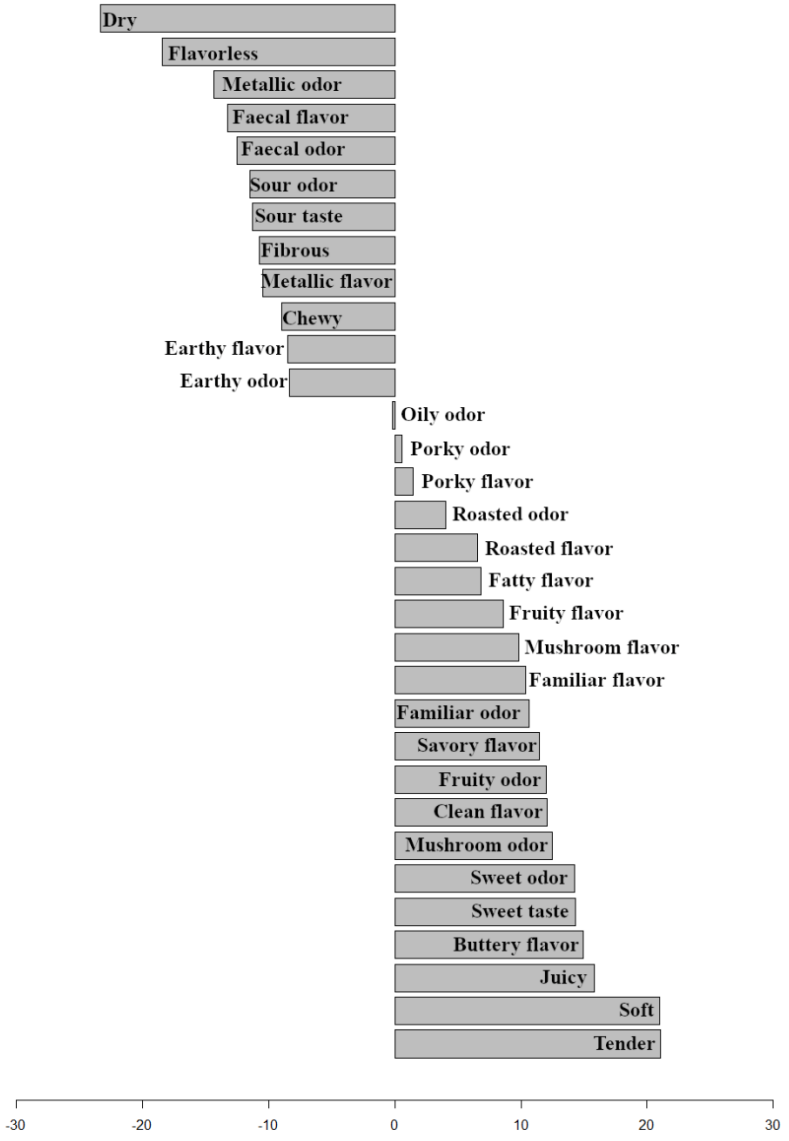


Figure 6. Penalty lift analysis of check-all-that-apply terms

3.2 Discussion

The major findings of the first study were that 1) the terminal lines had lower P2 fat depth but higher cooking loss, chewiness and hardness than maternal lines; 2) genetic line influenced the texture, collagen characteristics and IMF of pork, with line SynT-LWLR the toughest and leanest; 3) the SM showed higher chewiness than LTL with higher collagen and IMF content and lower collagen solubility; and 4) collagen characteristics and IMF content were related to pork texture in both muscles and in LTL. The significant findings of the second study were: 1) line PM-D had the highest IMF content; 2) line PT-LW was most preferred by consumers and lines of Landrace breed were the least preferred; 3) the SM received higher sensory scores than the LTL, with higher pH and collagen solubility; 4) CATA could differentiate between lines and muscles, but biometrics could not; 5) pH positively contributed to tenderness, juiciness and overall liking; 6) flavour is the most important sensory attribute contributing to overall liking, followed by

tenderness. Therefore, hypothesis 5) was accepted, while hypotheses 1), 2), and 4) were partly accepted, and hypothesis 3) was rejected.

Different lines showed different IMF content and sensory properties. In the present study, line PM-D showed the highest IMF content. This result aligns with previous studies, which found that pork from purebred Duroc pigs had a higher IMF content than Landrace and Large White (Cameron et al., 1990; Smith & Pearson, 1986). However, the results of sensory evaluation varied in the literature. Wood et al. (2004) reported that LTL from Large White received a higher tenderness score than Duroc. Cameron et al. (1990) found that consumers considered LTL from Duroc to be more juicy but less tender and had less acceptable flavour than LTL from Landrace, while Lo et al. (1992) reported that the sensory properties of LTL from Duroc and Landrace did not differ. The IMF content of pork in this study was lower than in previous studies (Cameron et al., 1990; Lo et al., 1992) but consistent with more recent studies in Australia (Li et al., 2022b). Due to differences in genetic selection between countries, meat quality could also vary within the same breed. In addition, different farms employ different rearing systems, leading to variations in growth rate and maturity, and consequently, differences in pork eating quality among studies.

Apart from the difference between breeds, genetic selection also changed meat quality. In experiment 1, which included five similar lines, line PM-LW had the lowest hardness (most tender) and was lower than that of PT-D. In addition, all lines had higher IMF content than in the second study. Pork chemical components and eating quality may have changed with genetic selection in the 3 years between sampling for the two experiments. Selection for leanness could reduce IMF and tenderness (Lonergan et al., 2001). In addition, Schwab et al. (2006) reported that Duroc pigs produced pork with higher IMF content, more pork flavour, and less off-flavour compared to contemporary pigs. Contemporary Duroc pigs have been selected for increased carcass leanness to meet market and packer demands over the past few decades, but this has resulted in reduced meat quality and consumer acceptance. Therefore, selection for leanness is generally at the expense of pork quality.

In the second sensory study, SM showed higher pH and collagen solubility than LTL, and consumers preferred it. However, the difference in pH was slight. Generally, pork LTL and SM had little difference in pH (Tomovic et al., 2014). Voutila et al. (2007) reported that collagen solubility did not differ between pork LTL and SM, while in the first study, the SM had higher total collagen but with lower solubility than the LTL, resulting in similar total soluble collagen in both muscles. The higher collagen solubility in SM observed in the second study may be related to a higher collagen turnover rate (Voutila et al., 2007). As pigs are slaughtered at a relatively young age in Australia, it is possible that muscle growth is still ongoing, and the growth rate of SM is faster than that of LTL. In addition to collagen solubility, sensory evaluation results differed from those of a previous study, where the authors found that SM was less tender than LTL (Wheeler et al., 2000). Here, LTL received higher scores in appearance and odour, likely because consumers were more familiar with this muscle. The SM was scored as more tender and juicy than the LTL, and the LTL was perceived as dry, as indicated by CATA. In the first study, the SM had higher cooking loss than LTL (Li et al., 2024), leading to lower juiciness in LTL. The perception of meat juiciness and tenderness is interrelated (Liu et al., 2020). Lower scores in juiciness of LTL result in lower scores in tenderness. Additionally, the SM was more flavourful than the LTL. It might be caused by the higher polyunsaturated fatty acids in SM, which improve the flavour profile of pork (Purchas et al., 2009). Also, consumers preferred the sour taste in LTL less. Therefore, consumers preferred SM over LTL.

In the sensory study, pH was positively related to tenderness, juiciness, and overall liking. This result agreed with previous studies (Guignot et al., 1994; Richardson et al., 2018; J. A. Silva et al., 1999). One of the mechanisms by which pH affects tenderness is that it influences the activity of proteases, which contribute to post-mortem proteolysis (Lomiwes et al., 2014). Additionally, the degree of doneness is lower for meat with a higher pH when cooked at the same temperature (Bouton et al., 1971; Brewer & Novakofski, 1999). pH also affects water-holding capacity. When the pH is higher than the isoelectric point of proteins (~5.2), myofibrillar proteins have a predominance of negative charges and repel each other, allowing more water to remain in the intermyofibrillar space (Huff-Lonergan & Lonergan, 2005). Therefore, pH affects the eating quality of pork.

The IMF and collagen contents had relatively small effects on the sensory attributes of pork. Previous studies reported no effect (Rincker et al., 2008; Wheeler et al., 2002) or significant effects (Huff-Lonergan et al., 2002; Wheeler et al., 2000) of IMF and collagen on pork sensory attributes. The insignificant effect of IMF in the present study could be due to its low concentration in the muscle, as it was lower than that of many studies (Fernandez et al., 1999; Huff-Lonergan et al., 2002), possibly because we were investigating superior terminal lines, concerning carcass leanness, that are the grandparents of most market animals. Other muscle components, such as myofibrillar proteins, play a more significant role in influencing eating quality. Therefore, the IMF had little influence on eating quality in this study. For collagen, the perimysium's strength decreases when cooked to above 50 °C (Christensen et al., 2000). In the present study, the final temperature of the muscles was around 72 °C, at which the strength of myofibrillar protein was at its maximum (Christensen et al., 2000). Meat is a complex matrix. Its components can behave differently when their concentration and environment change. Therefore, more studies are needed to understand the effects of the IMF and collagen on pork eating quality under different conditions.

Flavour, tenderness, and juiciness are the key sensory attributes for consumer evaluation of Australian pork. Among them, flavour is the most important sensory attribute contributing to overall liking in the present study, followed by tenderness. Similarly, Channon et al. (2016) reported that the slopes for liking flavour and tenderness were 0.618 and 0.235, respectively, in predicting the overall liking of pork LTL, Triceps Brachii, and *Biceps femoris*. Moeller et al. (2010) conducted a correlation analysis between sensory attributes of pork *Longissimus*, and they found that overall liking was most strongly correlated with liking flavour ($r = 0.79$), followed by tenderness liking ($r = 0.73$). Together with the results of penalty-lift analysis, it can be concluded that if the pork flavour is acceptable and pleasant, consumers will be concerned about tenderness. Appearance and odour are less important than other attributes in this study, as the cooking temperature was controlled. In contrast to pork, tenderness is the primary driver of liking in beef, while flavour is also the most important attribute in lamb, similar to pork (Miller, 2020). This also confirms that the MSA protocol is not applicable to pork. However, one limitation of this study was that there was a large portion of consumers with Asian cultural heritage, although they were all consumers of Australian pork. It will be worth investigating the opinions of British-Australians and indigenous Australians towards Australian pork.

In this study, CATA effectively differentiated muscles and lines, whereas biometrics did not. The CATA method is a rapid and reliable method to characterise food products, and it has some applications in meat and meat products (Henrique et al., 2015; Jorge et al., 2015). Silva et al. (2023) differentiated and characterised pork from pigs fed with different oil supplements using

CATA. CATA can be included in future sensory evaluation of pork for the pork industry. In contrast to CATA, the results did not differ between muscles or lines in terms of emotion. Torrico et al. (2018) reported a beef consumer test in which facially expressed emotions could discriminate between Biceps femoris (BF) stored in high-oxygen modified atmosphere packaging and BF and *Psoas major* in vacuum packaging. Similarly, Mena et al. (2023) found that an emotional analysis of consumers eating beef patties differentiated between younger and older consumers, as well as between soft and hard beef patties with or without added sauce. In the present study, videos were taken when most consumers assessed odour, which had fewer differences between samples as shown by CATA (Table 3). It is recommended that consumers' emotional responses be recorded when they are evaluating tenderness.

4. Application of Research

Genetic variation exists in muscle pH, collagen characteristics, IMF and sensory eating quality, and therefore genetic selection should be able to improve the eating quality of Australian pork.

Muscle pH was positively associated with the eating quality of pork such that an increase in pH of 0.1 units was associated with approximately 2 units in eating quality. On-farm and off-farm practices to reduce low pH will improve eating quality.

In the first study, IMF was positively related to objective measures of eating quality. However, relationships with sensory eating quality, while positive, were less pronounced in the second study. The small effects may be due to the low range in IMF encountered in this study, and further work is needed with a wider range in IMF.

In the first study, total muscle collagen was negatively related to objective measures of texture and tenderness. However, relationships with sensory eating quality were not apparent in the second study. The reasons for the disparate results are unknown, but it may be worthwhile investigating further.

Flavour was the most important sensory attribute in consumer evaluation of Australian pork, followed by tenderness. Future research should focus on the factors that affect pork flavour.

The CATA method effectively differentiated between muscle and line, but the biometric approach had limited performance. The CATA method should be incorporated in future pork sensory studies.

5. Conclusion

Genetic line and muscle affect pH, collagen characteristics, IMF and eating quality of pork. Line PM-D showed the highest IMF content, but consumers most preferred line PT-LW. A line from the Landrace breed received the lowest sensory scores. The SM had higher ratings in sensory evaluation than LTL, partly because of its higher pH and collagen solubility. In the first objective meat quality study, total muscle collagen was positively correlated with chewiness, hardness, and shear force. However, in the second study, collagen characteristics had little

influence on pork sensory eating quality. Flavour was the most important sensory attribute in consumer evaluation of Australian pork, followed by tenderness. The CATA method effectively differentiated between muscle and line, but the biometric approach had limited performance. Future studies can focus on breeding strategies or nutrition interventions to improve the flavour of pork.

6. Limitations/Risks

This research was conducted with pigs from a single supply chain, which may not accurately replicate what might happen with pigs from a different supply chain with a different genetic background.

For the sensory study, the participants were predominantly Asian (see Appedix) who may be particularly discerning about pork quality. Therefore, these data may not accurately reflect the responses of a broader demographic.

7. Recommendations

As a result of the outcomes in these studies, the following recommendations have been made:

1/ Genetic selection should include measures of eating quality to improve the eating quality of Australian pork. These may include increasing pH, improving flavour, reducing muscle collagen and increasing IMF.

2/ Nutritional strategies to improve pork eating quality need to be investigated. These may include increasing pH, improving flavour, reducing muscle collagen and increasing IMF.

3/ On-farm and off-farm practices to reduce low pH should be employed to pork improve eating quality.

4/Characteristics of optimal pork flavour need to be determined to maximise pork eating quality.

5/The CATA method should be incorporated in future pork sensory studies.

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Appendices

Table A1. Demographics of consumers

	Count	Percentage
Gender		
Male	78	34
Female	151	66
Age group		
20 or younger	28	12
21-30	144	63
31-40	23	10
41-50	11	5
51-60	15	7
61-70	5	2
70 or older	3	1
Cultural heritage		
Australian	23	10
Indigenous Australian	0	0
British	0	0
European	3	1
Asian	193	84
African	1	0
South American	2	1
North American	3	1
Other	4	2
Number of people in the household		
1	84	37
2	69	30
3	39	17
4	21	9
5	8	3
6	3	1
7 or more	5	2
Parent or guardian of any children age 18 or younger		
Yes	18	8
No	211	92
Occupation of the main income earner in the household		
Manager	28	12
Professionals (included health professional etc.)	35	15
Technicians and trade workers	10	4
Community and personal services worker	3	1

Clerical and administrative workers	4	2
Sales workers (includes retail sales etc.)	6	3
Machinery operators and drivers	1	0
Labourers	3	1
Home duties	6	3
Student	116	51
other	17	7
Household income		
under $25,000 per year	78	34
$25,000 - $50,000 per year	67	29
$50,001 - $75,000 per year	22	10
$ 75,001 - $100,000 per year	28	12
$100,001 - $125,000 per year	10	4
Over $125,000 per year	24	10
Pork consumption frequency		
Everyday	4	2
4-5 times a week	22	10
2-3 times a week	66	29
Weekly	73	32
Fortnightly	28	12
Monthly	26	11
Less than monthly	10	4
Total	**229**	**100**

Table A2 DEMOGRAPHICS QUESTIONNAIRE

This information is confidential and will be used for classification purposes only.

D1. Please indicate your gender. (Select one)

☐ Male [1]	☐ Female [2]	☐ Other [3]

D2. In which of the following age groups do you belong? (Select one)

☐ 20 or younger [1]	☐ 21–30 [2]	☐ 31–40 [3]	☐ 41–50 [4]	☐ 51–60 [5]	☐ 61–70 [6]	☐ 71-80 [7]

D3. What is your cultural heritage? (Select one)

[1] ☐ Australian
[2] ☐ Indigenous Australian
[3] ☐ British
[4] ☐ European
[5] ☐ Asian
[6] ☐ African
[7] ☐ South American
[8] ☐ North American
[9] ☐ Other. Please specify:_____

D4. Including yourself, how many people are living in your household? This includes infants but does not include students living away from home. (Select one)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 or more

D5. Are you the parent or guardian of any children age 18 or younger living in your household? (Select one)

☐ Yes [1] ☐ No [2]

D6. What's the occupation of the main income earner in your household? (Select one)

[1] ☐ Manager
[2] ☐ Professionals (included health professional etc.)
[3] ☐ Technicians and Trade Workers
[4] ☐ Community and Personal Services Workers
[5] ☐ Clerical and Administrative Workers
[6] ☐ Sales Workers (includes retail sales etc.)
[7] ☐ Machinery Operators and Drivers
[8] ☐ Labourers
[9] ☐ Home Duties
[10] ☐ Student
[11] ☐ Other

D7. Which one of the following ranges includes your total yearly household income, before taxes? (Select one)

☐	☐	☐	☐	☐	☐
Under $25,000 per year	$25,000–$50,000 per year	$50,001–$75,000 per year	$75,001–$100,000 per year	$100,001–$125,000 per year	Over $125,000 per year
[1]	[2]	[3]	[4]	[5]	[6]

D8. How often do you consume pork? (Select one)

[1] ☐ Everyday
[2] ☐ 4-5 times a week
[3] ☐ 2-3 times a week
[4] ☐ Weekly
[5] ☐ Fortnightly
[6] ☐ Monthly
[7] ☐ Less than monthly

Table A3 Hedonic scales empliyed

Sample No. _____ **Participant code: _____**

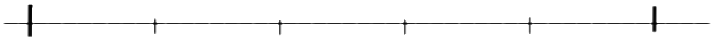
Follow the test instructions closely. You will be provided with 7 individual samples which all require a test. Each sample will have two portions.

Please inspect, smell and then eat one portion the sample provided. Once you have finished fill out the questions below in section (1).

When you have completed section (1), eat the second portion, then select all attributes that apply in section (2). Then eat some cracker, drink some water and wait for the next sample.

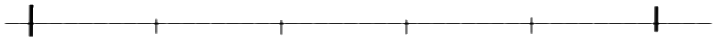
(1)

Liking of appearance



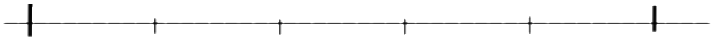
Dislike Extremely — Like Extremely

Liking of odor



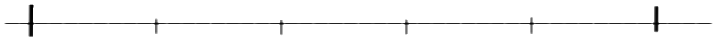
Dislike Extremely — Like Extremely

Tenderness



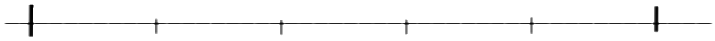
Not Tender — Very Tender

Juiciness



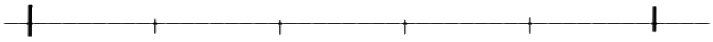
Not Juicy — Very Juicy

Liking of flavor



Dislike Extremely — Like Extremely

Overall Liking



Dislike Extremely — Like Extremely

Do you detect any off-flavor?

Yes [ ] No [ ]
[1] [2]

To what extent would you purchase this product?

I definitely would not buy it [1] ☐
I would probably not buy it [2] ☐
I might buy it [3] ☐
I would probably buy it [4] ☐
I would definitely buy it [5] ☐

Please tick one of the following to

Rate the quality of the pork sample you have just eaten
Choose **one** only (you must make a choice).

Unsatisfactory | Good everyday quality | Better than everyday quality | Premium

(2) Please check the words or phrases about odor and texture which best describe the pork sample you have just tried.

Faecal odor	☐	Tender	☐	Sweet odor	☐
Roasted odor	☐	Chewy	☐	Dry	☐

Soft	☐	Oily odor	☐	Mushroom odor	☐
Metallic odor	☐	Fibrous	☐	Earthy odor	☐
Juicy	☐	Sour odor	☐	Fruity odor	☐
Familiar odor	☐	Porky odor	☐		

(3) Please check the words or phrases about flavor which best describe the pork sample you have just tried.

Faecal flavor	☐	Fatty flavor	☐	Sweet taste	☐
Roasted flavor	☐	Tasteless flavor	☐	Earthy flavor	☐
Porky flavor	☐	Sour taste	☐	Metallic flavor	☐
Buttery flavor	☐	Fruity flavor	☐	Mushroom flavor	☐
Clean flavor	☐	Familiar flavor	☐	Savory flavor	☐