final report

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Benchmarking the eating quality of the UK beef industry using MSA consumer sensory protocols

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Abstract

This project with the UK Agriculture and Horticulture Development Board (AHDB) implemented MSA protocols to evaluate 6 cuts derived from Achilles (AT) and Aitch Bone (TX) hung sides of 18 cattle slaughtered in Wales and aged 21 days post mortem. The cattle included 9 young bulls, 6 heifers and 3 steers. The objective was to facilitate evaluation of UK consumers response across a comprehensive quality range and to provide some limited indication of individual cut x hang interactions.

UK consumers displayed high discrimination in segregating beef quality bands with 'Willingness to Pay' data also demonstrating substantial value differences in line with quality ratings. Clear eating quality differences were identified by consumers between cuts and hang methods. Niether EUROP muscle or yield scores were correlated with consumer assessment.

Consumer assessments indicated a wide quality range across two or more MSA based quality levels within each cut. The cut and hang ratings were similar to Australian findings other than a lower rump rating and greater aitch bone discount for tenderloin. The sex effects displayed a non-significant, increasing quality trend from bull to heifer to steer.

An effective prediction model for UK consumers and beef is plausible and supported by initial evaluation utilising existing MSA and related models.

Executive summary

The project was initiated to provide a Meat Standards Australia (MSA) benchmark for typical beef produced in the United Kingdom and evaluated by UK consumers. AHDB and previous related organisations have conducted substantial research into beef eating quality and consumer response over many years. The Australian MSA program was initiated in the mid 1990's and elected to use untrained consumer evaluation as the primary measurement tool to determine the relationship and inter-relationship of factors that impacted eating quality.

The initial approach sought to utilise defined "Pathways", sets of multiple criteria that sought to remove unsatisfactory product to leave a defined consumer established satisfactory quality level. This approach borrowed heavily from the then Meat and Livestock Commission in the UK and other Palatability Critical Control Point work presented by Morgan in the USA.

Over a period of years this approach was found to be impractical within the extreme range of Australian cattle types and production systems. When a set of parameters were established that removed undesirable product a substantial proportion of acceptable product was also removed; when one or more parameters were adjusted to provide acceptable volume an undesirable level of unsatisfactory product was included. The problem and Pathway complexity became greater as the number of cuts was increased.

The solution for MSA was the development of an interactive prediction model that could adjust for each potential grading input and interactions. This provided a means to effectively segregate a very high percentage of consumer acceptable product, subsequently divided into 3 quality levels, while removing a very high percentage of unsatisfactory product. The model and its successors have proved effective at predicting consumer response across muscles, cooking methods and ageing periods for cuts derived from widely divergent cattle and production backgrounds.

The UK environment is believed to be substantially more uniform and two large contributors to reduced eating quality in Australia, hormonal growth promotants and Brahman cattle are not present in the UK herd. The UK production system however differs in extensively utilising continental and dairy breeds and crosses and a moderate percentage of young bulls with a mix of pasture and concentrate diets. The Australian MSA data is difficient for these influences which could render an Australian developed grading approach less or inneffective. Prior studies in Ireland, Northern Ireland, France and Poland have reported a useful but not fully accurate alignment with local cattle and it is believed that by combining data produced under common protocols an improved prediction

could be possible. Current work under the UNECE Specialised section in Meat is investigating arrangements to achieve collaboration and data sharing for the common good.

Currently all EU cattle are compulsory graded under the SEUROP system which effectively estimates yield but not eating quality. As the SEUROP grading must be reported it is also the principal pricing base for trading cattle to factories. Individual, generally retailer imposed, additional criteria such as Farm Assurance, breed and age specifications are often superimposed with related price incentives to underpin presumed eating quality standards. Further requirements, often reflecting the AHDB Blueprint, are common for the factories. To date however these approaches are applied at carcase level so apply to all cuts with the retailer anticipating that individual cuts will be uniform across cattle supplied.

While AHDB and MLA have independently worked to improve meat eating quality and consumer value the methodologies have been different making results from either system difficult to translate to the other. Even where both groups have conducted consumer evaluation the protocols differ sufficiently to make any safe direct comparison difficult. With the advent of Brexit AHDB have been consulting with the UK industry about potential opportunities to modify grading and description systems independant of EU agreement. There is also renewed interest in trade agreements between the UK and Australia.

These circumstances underpin a mutual interest in establishing benchmarks to enable connection between the two industries and examine where systems might be complementary. An important starting point was seen as linking consumer sensory response to a range of product quality to gain an initial understanding of UK consumer sensory response and to establish to what extent UK cattle might vary given a more consistent production background.

This project with the AHDB used MSA protocols to evaluate 6 cuts derived from Achilles (AT) and Aitch Bone (TX) hung sides of 18 cattle slaughtered in Wales and aged 21 days post mortem. The cattle included 9 young bulls, 6 heifers and 3 steers. The cuts were evaluated as grilled steak by 360 UK consumers over a 4 month period with each consumer scoring 7 samples in a controlled order that balanced presentational order with each sample being tested by 10 consumers.

The objective was to facilitate evaluation of UK consumer response across a comprehensive quality range and to provide some limited indication of individual cut x hang interactions.

The resulting data was analysed to firstly establish appropriate weightings for tenderness, juiciness, flavour and overall satisfaction to create a composite MQ4 score between 0 and 100 and then to establish appropriate cut-off scores that best segregated 4 quality levels described as unsatisfactory,

good everyday (3*), better than everyday (4*) and premium (5*) quality. While the score weightings were similar to those utilised in Australia (T*0.3 + J*0.1 + F*0.3 + O*0.3) the UK consumers utilised a more extreme score range (ie marking more samples at the anchor points than typical) with a consequence being slightly lower unsatisfactory/3* and slightly higher 4*/5* cut of scores.

These extremes were further found in UK Willingness to pay (WTP) data with unsatisfactory product being valued at 38.5% of 3*, 4* at 150.5% and 5* at 212.6%. The very low unsatisfactory to 3* % compares to a more normal 48 to 52% range and if confirmed in further work indicates a strong message in regard to the risk of unsatisafactory product on consumer response.

The individual cut scores and relative rankings were similar to previous MSA research in multiple countries in most regards as were the Achilles (AT) versus aitch bone (TX) carcase suspension results with a lower score for rump and greater negative tenderloin impact from TX the major deviations. Each cut had a score range that encompassed at least two quality categories indicating that cut alone or cut x sex could not adequately describe consumer satisfaction. As expected there was no relationship between SEUROP muscle or fat scores and consumer scores.

The results, while from a modest level of data, establish that UK consumers are at least as reactive to eating quality variation as other consumer populations, and perhaps more so. Significant quality variation was also found within the cattle tested and also within each cut indicating that improved segregation, reflecting consumer response, could improve the beef value offer.

An effective prediction model for UK consumers and beef is plausible and supported by initial evaluation utilising existing MSA and related models. Further collaboration with MLA and other partners with an interest in eating quality, combined with further UK testing, could expand existing source data and enable development of an efficient model if desired. A significant technical objective of great potential industry value could be a combination of SEUROP and a quality prediction model to balance the value of yield and consumer satisfaction. Adoption of this within pricing systems could encourage substantial industry change and consumer alignment.

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1 Project objectives

This project will use the MSA model and MSA consumer sensory protocols to benchmark the eating quality of the UK beef production system and UK consumer against the MSA Standards. Meat Standards Australia (MSA) delivers an eating quality program across the beef supply chain focussed on managing and measuring factors that impact on eating quality for the final consumer. The MSA program has been developed upon over 700,000 consumer taste tests and is now widely adopted in Australia to underpin the eating quality of beef brands. Through an eating quality analysis of processors and livestock types processed in the UK including consumer sensory testing, this collaborative project will provide insights into the eating quality of the UK beef industry using the MSA model as a benchmark as well as further understand the application of the MSA model for non-Australian consumers. The project will utilise carcase grading measurements and consumer sensory protocols that have been accepted by the UNECE Language within the Specialized Section on Standardisation of Meat

2 Methodology

The methodology employed in each trial component is summarised below. The over-riding trial objective was to provide a robust demonstration of MSA procedures and protocols utilising a UK production environment with product evaluation by UK consumers. The results provide an initial benchmark of UK consumer sensory response relative to other international populations, an indication of consumer satisfaction and assessed quality levels across a range of beef cuts sourced from different typical cattle types and an indication of Aitch bone versus Achilles carcase suspension, a key processing input.

2.1 Trial Design

The trial design was developed to provide a practical demonstration of MSA procedures and training in conjunction with data collection representing a number of factors known to impact on eating quality. A number of alternative designs were considered and discussed prior to agreeing on the final proposal. Budget constraints placed a finite limit on the number of consumers (360) that could be utilised which in turn determined the number of samples (252). Alternatives included testing more cattle and fewer cuts, more cuts and fewer cattle, fewer cuts with more than 1 ageing period, fewer cuts with multiple cooking methods etc.

The agreed design utilised 18 cattle with a mix of 9 young bulls, 6 heifers and 3 steers sourced from commercial suppliers. The weighting toward young bulls was greater than the 20% or so found in the

typical factory supply but elected to provide further data for potential MSA model adjustment as there are very few bulls in the MSA database.

It was agreed to include a within animal aitch bone (tenderstretch TX) versus Achilles (AT) carcase suspension comparison as this was known to have a differential but significant effect on muscle eating quality and has been widely used in the UK market for many years as has traditional AT.

Further product variation was sought by including 6 diverse muscles from common wholesale cuts being fillet/tenderloin (*m.psoas major*), sirloin/striploin (*m.longissimus dorsi et lumborum*), rump (heart - *m.gluteus medius*), topside (*m.semimembranosus*), bullet/knuckle eye (*M.rectus femoris*) and feather/oyster blade (*M.infraspinatus*). To accurately assess consumer sensory response it is important to ensure that each consumer is served an expected range of quality which in turn ensures that relative weightings for sensory variables such as tenderness, juiciness and flavour can be evaluated within a quality framework; tenderness may be more important at the lower end and flavour at the higher etc.

Due to the relatively low sample numbers available a single ageing period of 21 days and the grill cooking method was selected.

The final design elements were entered into MSA Cut Up Developer (CUD) software to produce Acquisition recording sheets, a balanced sample design, a sample fabrication (CutUp) recording file and unique sample labelling.

2.2 Product collection

A site visit was made to the Welsh factory on Monday June 5th 2017 to confirm arrangements for the kill and collection. On June the 6th MSA, AHDB and Polkinghornes personnel inspected cattle groups in lairage to determine a suitable mix. The final 18 head to be utilised were identified as they passed through the eartag reading crush and drafted off to slaughter. A knock time was recorded at the knocking box and the hide puller electrical input time observed.

After passing the scale and EUROP grading station the selected side of each carcase was aitch bone (TX) hung as directed prior to chiller entry and the time recorded. TX suspension was applied to an equal number of left and right sides to balance any potential legging effect. (The period to first leg on the kill floor is effectively close to a TX orientation for the non shackled leg which may impact the result where very rapid pH declines are encountered). This factory utilised electrical stunning which may have an impact on pH decline and had not been evaluated by MSA. The trial carcasses were placed on a single chiller rail to assist in access for pH measurement and grading.

From chiller entry pH and temperature measurements were recorded at hourly intervals for 5 hours to provide pH and temperature decline data. Large laminated labels were prepared for each carcase quarter numbered 1 to 18 with Left, Right, FQ and HQ notation for carcase identification and coloured by hang method for each side. The laminated tickets were affixed to each quarter utilising 150mm stainless steel skewers to provide quarter identification during boning.

All available data on the animal source, travel time, time in lairage and passport detail plus carcase weight and EUROP grade was recorded including linkage of source animal ID to carcase number.The cattle were deboned on Thursday June 8th. Prior to marshalling for boning all carcasses were MSA graded and a DNA sample taken from the quartered rib surface. The laminated quarter tags were positioned in the sirloin/striploin and feather/oyster blade and checked with the 1 to 18 CUD number aligned with actual carcase number.

The deboning hall at the plant utilises a CARNE quarter boning system with each of the designated cuts removed at different stations along the chain. The chain layout and cut identification requirements were discussed with the boning hall manager prior to quartering. After quartering the sirloin/striploin laminated tag was transferred to the topside and the security of all tags confirmed. Small 50mm x 38mm laminated Primal Tickets had been previously produced from the CUD documentation. These carried the carcase number, 1 to 18, left and right designations to align with the large quarter tickets plus a cut description and a unique 5 digit primal number reference.

Factory, MSA, AHDB and Polkinghornes staff were positioned at designated positions along the chain. As the quarter reached a position the matching Primal ticket was placed on the relevant cut as it was removed. The cuts and tickets were then transferred to a separate area of the deboning hall and held in plastic crates for further fabrication. The loins were removed as shortloins and transferred to a specific table at the rear of the deboning hall where they were fully deboned and the Primal tickets assigned. When all cuts had been successfully acquired a designated area at the rear of the deboning hall was reconfigured to create a processing station for sample fabrication.

The sample fabrication process followed MSA protocols. Each cut was fully denuded by factory butchers and reduced to a single muscle with silverskin removed. The denuded muscle was then placed on a sheet and moved to a recording station where pre-printed Avery self adhesive labels were placed in an order paralleling the muscle orientation to designate the required fabrication. The Avery label displayed the 5 digit primal number utilised as the reference point for each Primal ticket. In addition a unique 4 digit alphanumeric code and associated sequence number was introduced and utilised as the primary identification from fabrication to consumer testing. This “EQSRef” code was linked by software to primal, side, carcase and animal. The Avery label also included a cut code,

cooking method, muscle position and date to be frozen to achieve 21 day ageing. Each label/sample was checked off a master record sheet produced from the CUD software. The sirloin/striploin had three designated positions while the other muscles had one only. The muscle and label(s) were then moved to a cutting station.

Each muscle was placed on a cutting jig with the grain direction oriented along the jig at right angles to the cutting face. The cutting jig was set to provide a 25mm slice thickness. The muscle end was firstly squared off and then a number of 25mm slices produced. Five sensory steaks, each approximately 65mm x 35mm, were then prepared from the slices. Three separate sets were produced from the sirloin/striploin with two designated as “Links”, samples to be served first in subsequent sensory testing. The position of the main sensory sample was rotated across the three designated positions to allow calculation of a muscle x position effect.

After fabrication the 5 steaks were individually wrapped in freezer sheet and placed in vacuum bags with the Avery label affixed. The bags were then vacuum packed and stored in plastic crates at 1˚C in the factory coldstore for ageing. All samples were transferred to a freezer 21 days from kill.

The completed CUD files were then electronically confirmed as all samples being obtained and a further software process enacted to move the samples, designated as “Available”, and associated data such as cut, position, primal number and carcase number, side, suspension etc to the MSA AUSBlue database.

Surplus scrap material from the knuckle cover and topside cuts were also sliced into larger irregular pieces of 25mm thickness and packed as “Starters” for use in stabilising the initial grill temperatures during sensory testing. In addition to sensory samples AHDB staff collected sirloin and topside blocks to enable subsequent laboratory analysis as desired.

2.3 Pick and Post

The fabricated samples were assigned to consumer picks utilising a layout that sought to provide each consumer with a wide eating quality range. As depicted in Table 1 each cut was assigned to a product with the sirloin/striploin and rump aligned with hang in line with an expected outcome that the hang effect would outweigh the muscle difference. The six samples within each product were drawn from a mix of sex groups to ensure they were evaluated by common consumer groups. The Table 1 layout was utilised for three picks with the cuts on any one row from common animals to provide tight cut within animal linkage. For the remaining three picks where steer cuts were not available cuts from three bulls were assigned across picks and the other three fully within pick to provide inter-pick connection.

Table 1. Pick design utilised for cut allocation to consumer testing

	PRODUCT 1	PRODUCT 2	PRODUCT 3	PRODUCT 4	PRODUCT 5	PRODUCT 6
Bull	Topside AT	Bullet AT	Sirloin AT	Sirloin TX	Feather AT	Fillet AT
Bull	Topside TX	Bullet TX	Rump AT	Rump TX	Feather TX	Fillet TX
Steer	Topside AT	Bullet AT	Sirloin AT	Sirloin TX	Feather AT	Fillet AT
Steer	Topside TX	Bullet TX	Rump AT	Rump TX	Feather TX	Fillet TX
Heifer	Topside AT	Bullet AT	Sirloin AT	Sirloin TX	Feather AT	Fillet AT
Heifer	Topside TX	Bullet TX	Rump AT	Rump TX	Feather TX	Fillet TX

MSA sensory software assigned every consumer one sample from each product with the order of serving varied and balanced by utilising a 6 x 6 Latin square.

The pick design was enacted by a process referred to as “Pick and Posting”. MSA software was utilised to select and allocate available samples to a specific pick position as represented by the Table 1 layout. After assignment a pick list was produced to facilitate sample sorting to the nominated pick and then the pick was “posted”. The posting software assigned each of the five steaks within each sample to a specific 2 consumers in a specified serving order. This order was controlled by the 6 x 6 Latin square allocation that ensured each product was served an equal number of times in each order position and equally before and after each other product to balance out potential order and halo effects. To further address potential consumer group effects each of the 5 steaks within each sample was allocated to a consumer pair within 5 subsets of 12 consumers within the 60 in a pick. As the 60 were served in three sittings of 20 people this also resulted in the steaks from any sample being dispersed across multiple sittings.

The Link samples are not included in the table or discussion above but involve 6 further samples of 5 steaks. Two Link samples are cooked first within each session of 20 consumers and served in first position only. Consequently consumers received a common sample, estimated to be of mid quality, as their first sample with each link sample dispersed across 10 consumers.

The design was completed and associated files printed prior to travel to Wales. After a site visit on September 14th to finalise the plant arrangements Siobham Slayven and Rod Polkinghorne sorted all frozen samples into the 6 picks on September 15th. Sorting was conducted per MSA protocol utilising a cross call of Sequence number and EQSRef code to reduce the chance of error. All samples were successfully found and the picks confirmed.

The picks were then returned to the freezer to remain frozen and returned to a 5˚C work area for posting with 4 picks posted on Friday September 15th and the remaining 2 on Tuesday September 19th.

The posting procedure involved the transfer of the 5 individual samples within each of 42 sample bags to one of 10 specified positions on 21 “Round Sheets”. The round sheets have 10 EQSref and associated Sequence numbers printed on an A4 sheet which is placed within a waterproof sleeve in turn placed within a 250 x 350mm vacuum bag. Each Round Sheet is subsequently utilised during cooking to control the order steaks are placed on the grill and subsequently served.

Prior to posting the 42 sample bags were laid out on a table in alphanumeric order, the bags cut open and the 5 frozen steaks broken apart and checked to confirm a count of 5. A round sheet and vacuum bag was then placed on a clipboard with one person calling the first EQSRef code. The second person located the bag and called back the matching Sequence number. When confirmed a single steak was passed and placed within the bag on top of the printed EQSRef position. This was repeated until the sheet had 10 steaks arranged in a 3 – 4 – 3 pattern. For the 3 Link sheets (Round 1 of each session) two bags were fully utilised. For all other sheets (Rounds 2 to 7 for Sessions 1 to 3) each sheet had one steak from 10 different bags. Each sheet was vacuumed to hold the frozen steaks in position as completed and the 7 sheets for a session packed into individual boxes labelled with the pick and session number and returned to the freezer.

2.4 Sensory Testing

Sensory testing and associated training in procedure commenced at the Pontypool Rugby Club on Saturday September 16th with the Rugby club recruiting 60 consumers that met screening criteria of being regular beef eaters (at least once per two weeks), between 18 and 70 years old and preferring beef cooked medium. A £600 fee was paid to the club for providing the consumers together with a venue hire payment replicating MSA procedures in Australia.

The samples for the pick were transferred from the factory freezer to chilled storage 24 hours prior to the sensory session to thaw.

Organisational difficulties in hiring a three phase generator and relocating the Silex clamshell grill nominated in the MSA protocol from Belfast resulted in a major protocol change on the morning of the first session. This involved substitution of a Silesia Velox CG-2 double plated clamshell grill unit powered by dual single phase circuits. Surplus starter samples were quickly fabricated into the equivalent of grill samples and rounds and a series of tests conducted with the substituted grill. Fortunately the standard timing charts proved to be appropriate after temperature adjustment enabling the session to proceed. Amendments to the protocol included allocation of steaks across the two grill plates with 5 to each and placement adjusted to ensure ID was maintained if steaks were displaced as the top plates were lowered. An amended protocol enabling use of the Selesia Velox CG-2 was subsequently produced for future work. This protocol is attached as an appendix.

Sample consumer questionnaire files had been previously emailed to AHDB and adapted to relate to UK demographic equivalents. A copy of the questionnaire is attached as an appendix. Questionnaires had been printed by AHDB and transported to Pontypool together with a comprehensive list of required consumables such as plates, plastic cutlery, napkins, pens, cups, paper towel etc together with re-usable equipment items such as plastic serving trays, thermometers, jugs and tongs.

A further file of EQSRef codes with associated consumer, session and round detail was produced by the MSA software and printed on 65per sheet Avery labels. These labels were brought to Pontypool and transferred to the plates and questionnaire pages. AHDB and contract staff were instructed in the procedures to efficiently transfer the labels while maintaining order for serving sequence. Initial labelling was directly supervised and further training provided in transfer of plates to serving trays and arrangement to ensure trays were stacked in reverse serving order ensuring that the flow of cooked samples would align with the allocated consumers and sample serving sequence.

Key AHDB and contract staff members were allocated to manage the consumer area, serve samples, remove used plates, check sensory forms and to the cooking process. A table layout was agreed in the main Rugby Club hall and instruction and training provided in fabricating dividers to seat 4 consumers at a table. Labelling of booths with consumer numbers, and required changes between rounds, placement of questionnaires, consumables and dilute apple juice was explained and overseen.

A rugby club leader, Leighton Jones (also a key contact at the factory) was assigned to brief each session of consumers and provided with written notes detailing the information to be covered including describing the scoring process.

To avoid issues with smoke from the grill triggering fire alarms in the main building the grill was located under an external verandha as displayed in Figure 3. To reduce the risk of power supply being lost through excessive current draw two independant electrical circuits were used for the grill.

After confirming the temperature settings the grill was maintained at temperature until the first 20 consumers were seated. At this point two count up timers were started and scrap “starter” samples placed on the grill to standardise temperature. A timing chart, as shown in Figure1 was precisely followed to determine when the top plates were lowered, steaks removed, the next round placed on the grill and the steaks cut in half and served.

Time Sheet for Steak Cooking on SILEX

Times are minutes and seconds elapsed since "START".

Round No.	*Unload Steaks*	Load Next	*Close Lid*		Cut Up & Serve	
Prelim.		*START*	*00:30*			
Scraps	*05:00*	06:15	*07:00*			
1	*12:00*	13:15	*14:00*		15:00	
2	*19:00*	20:15	*21:00*		22:00	
3	*26:00*	27:15	*28:00*		29:00	
4	*33:00*	34:15	*35:00*		36:00	
5	*40:00*	41:15	*42:00*		43:00	
6	*47:00*	48:15	*49:00*		50:00	
7	*54:00*				57:00	*END*

Figure 1. Silex timing chart used to control cooking sequence.

The 7 round sheets for each session, identified as xxx-1-1 to xxx -1 – 7 etc were laid out on plastic trays in serving order. The vacuum bag was cut open and the top laid back to expose the 10 steaks. Each of these had the freezer film removed and was placed back in position confirming that the tray was “right way up” by orientation of the codes. The trays were allowed to warm to air temperature (approximately 10˚C) and placed in cooking order adjacent to the raw product side of the grill.

The starter scraps were removed from the grill at the designated time on the cooking chart and the grill plates scraped clean. A light spray of olive oil was then used on both grill plates and the 10 steaks on the first round sheet transferred to the grill at the time designated on the cooking chart. A strict order of placement, as shown in Figure2 being top left to right and top to bottom was followed to ensure sample ID was maintained and cook timing standardised in line with MSA protocol.

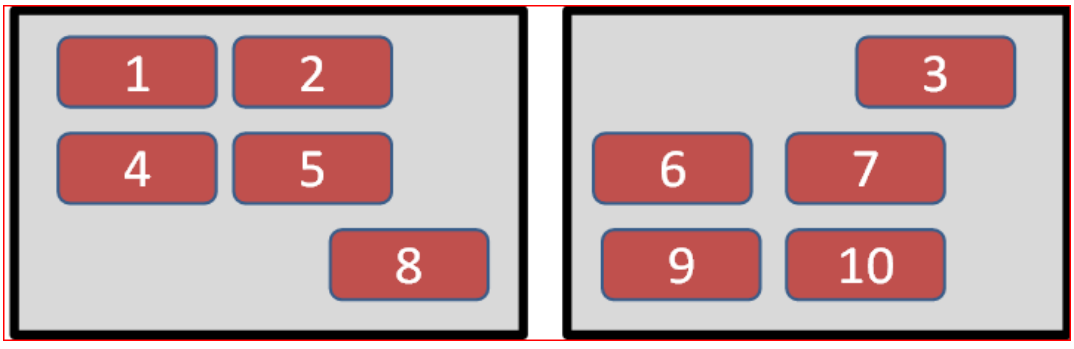


Figure 2. Steak placement on Selesia Velox grill to retain sample position and even heating

The top plates were lowered at the chart designated time and the empty round sheet transferred to a tray behind the cutting board on the take-off side of the grill. The round was cooked until the take off time was reached. At this point the two top plates were raised, checking for any samples adhering to the plate, and the steaks transferred to the cutting board in the same left to right, top to bottom sequence utilised in loading. While the cooked steaks were rested the grill was again cleaned, olive oil sprayed on the plates and the next round loaded at the designated time. Figure 3 displays the general cooking arrangement at Pontypool.

Figure 3. Cooking arrangement at Pontypool Rugby Club. Note Silesia grill in centre.

The rested cooked steaks were then halved at the time specified on the cooking chart and the two halves transferred to consumer plates in the same left to right, top to bottom sequence followed in loading and unloading the grill. A cross check of sample ID was made by calling the EQSRef code on the round sheet position and confirming each aligned with the EQSRef code on each pair of plates. Servers then carried the trays with 4 plates on each to the serving area where each plate was delivered to the consumer number printed on the plate label. A check was made to ensure the questionnaire page EQSRef code was identical to that on the plate label.

Each consumer marked 4 line scales for each sample labelled as tenderness, juiciness, flavour and overall with the line scales 100 mm long and the mark consequently reflecting a score between 0 and 100 for each trait. The tenderness scale was anchored with the words not tender and very tender, juiciness with not juicy and very juicy and the flavour and overall liking scales with dislike extremely and like extremely. In addition the consumer was asked to mark a single category box for each sample describing the sample as unsatisfactory, good everyday, better than everyday or premium quality. Staff cleaning away the used plates checked that the scoring page was completed.

The process was repeated for each of the 7 rounds in a session and then repeated for sessions 2 and 3. At the completion of each session (after serving of round 7) consumers were asked to mark a further line scale denoting price from £0 to £40 per kg of steak with a line for each of the previous category descriptions.

The completed questionnaires were then collected for measuring and recording by two independent AHDB staff.

Two further picks had been planned during the training visit but only one further session proved to be available in practice due to difficulties in obtaining a venue on the required dates. Consequently only a further single session was able to be conducted as an oversighted training session. This was conducted at Stoneleigh Park, the AHDB and many other agricultural organisation headquarters, near Kenilworth UK on Monday September 18th. The venue was a farm shop on the site with an excellent consumer seating area but unfortunately located on a second floor above the kitchen which was also extremely busy and restricted for space. The kitchen staff were extremely accommodating and an undesirable but ultimately successful cooking and serving layout was established. Further AHDB staff were trained in the cooking and serving procedures and the session successfully completed in accordance with protocol.

The remainder of the 6 sensory picks were conducted under the management of Siobhan Slayven who is to be commended on her dedication and hard work in taking responsibility for the recruitment and delivery of extensive sensory testing across many venues and for ensuring all data was double keyed, checked and emailed for processing.

The 60 questionnaires from each pick were independently coded by two people and entered into files supplied from MSA sensory software that had the sample codes listed for each consumer and a check function. Each line scale marking was measured in mm from the left hand end to denote a score out of 100. Where a discrepancy of more than 1mm was noted the sheet was re-checked.

3 Results

3.1 Consumer analysis

The consumer score distribution indicated that UK consumers clearly recognised differences in eating quality with MQ4 scores widely distributed and consistent with the selected category (2 = unsatisfactory, 3 = good everyday, 4 = better than everyday and 5 = premium quality) as illustrated in Figure 4 with the vertical blue lines indicating cut-off values for unsatisfactory/3*, 3*/4* and 4*/5*.

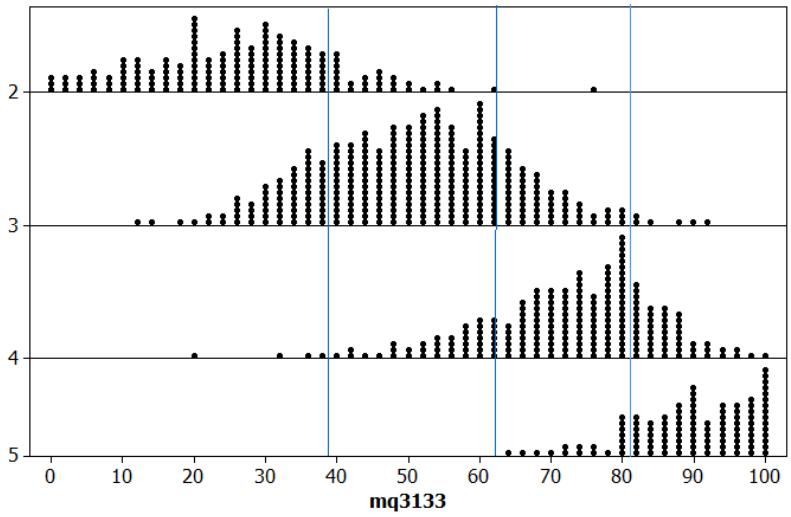


Figure 4. Dot plot of consumer MQ4 scores in relation to "standard" 3:1:3:3 weightings.

The distribution of scores within category is further illustrated in Figure 5 with the clear separation of the box plots indicating good discrimination.

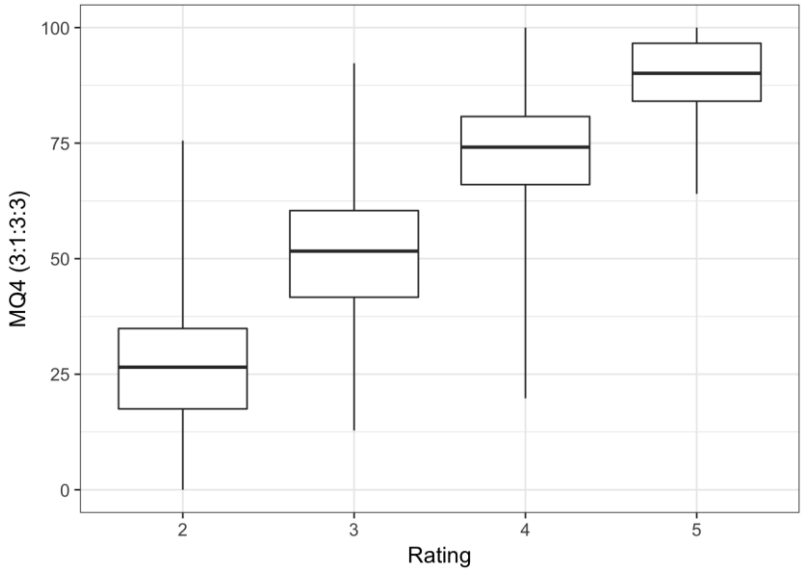


Figure 5. Box plot representation of consumer scores in relation to selected quality category.

Following MSA procedure (Watson et al, 2008) discriminate analysis was conducted to firstly define UK consumer sensory response. This effectively established consumer standards against which product could be measured. The analysis determined the relative importance (weighting) of tenderness, juiciness, flavour and overall liking for a consumer population with the weightings then used to create a composite MQ4 score with a 0 to 100 range. Optimal cut-off MQ4 scores were also established to best segregate consumer allocated quality levels or grades.

The consumer analysis was calculated on two basis: with all four variables and then on 3 variables with the overall scale removed to investigate the underlying driver of the overall rating. The final MQ4 for use in reporting was then calculated as an average of the 4 and 3 scale analysis. Similarly the optimal scale weightings for each quality class were calculated and a smoothed common weighting applied across all categories for operational use and analysis.

Table 2 displays the 4 scale analysis to the left with optimal weightings for these data – for example tenderness is shown as 0.11 for the Unsatisfactory/3* boundary and as 0.28 for 4*/5* discrimination with an average of 0.21 across all categories.

Table 2. Calculated weightings and cut-off scores with 4 and 3 scale discriminate analysis.

4 Scale Analysis						3 Scale Analysis						
	U/3*	3*/4*	4*/5*				U/3*	3*/4*	4*/5*			
0.698	38.2	62.3	81.6	Optimum		0.655	39.6	61.6	80.9	Optimum		MQ4
				Mean						Mean		
Tend	0.11	0.23	0.28	0.21		Tend	0.32	0.41	0.39	0.38		0.29
Juicy	0.04	0.06	0.13	0.08		Juicy	0.14	0.13	0.18	0.15		0.11
Flav	0.05	0.07	0.18	0.1		Flav	0.54	0.46	0.42	0.47		0.29
Overall	0.80	0.63	0.41	0.62								0.31
0.678	38.7	62.1	81.5	3:1:3:3								

The 3 scale analysis to the right indicates that when the overall scale is removed tenderness increases to 0.38 whereas flavour increases from a 4 scale weighting of 0.10 to 0.47 indicating that flavour is a strong driver of the overall appreciation. The MQ4 represents the MQ4 weightings derived from averaging the 3 and 4 scale results.

The optimal cut-off scores to segregate the 4 grades are shown at the top of each table being 38.2, 62.3 and 81.6 for example in the 4 scale table. The box to the left (0.698 for the 4 scale) reflects the consistency of consumers. This is the proportion of category choices (U, 3*, 4* and 5*) correctly determined by the weightings applied and as such is a measure of consumer consistency rather than meat or prediction.

The MQ underneath the tables (38.7. 62.1, 81.5) are cut-off scores using the “standard” MSA weightings of 0.3 Tend:0.1 Juicy:0.3 Flav:0.3 Overall which are shown to deliver very similar accuracy (67.8) to the optimal calculations for these data.

Willingness to pay data was collected from all consumers after they had scored 7 samples representing a wide quality range. For each of the four category descriptions (unsatisfactory, good

everyday, better than everyday and premium) a line scale graduated in £/kg was marked to reflect the consumer assessed value for that quality.

The results shown in Table 3 indicate substantial value differences between the quality levels with a particularly strong discount for unsatisfactory relative to good every day (3*). The percentage discount relative to 3* is greater than the more common 48 to 52% reported in other studies and, if substantiated in later work, would highlight the critical importance of consistently delivering a consistent acceptable or better product to UK consumers.

Table 3. Willingness to pay (WTP) results for 360 UK consumers

	Unsatisfactory	3*	4*	5*
£/Kg	£4.22	£10.96	£16.49	£23.31
% of 3*	38.5%	100.0%	150.5%	212.6%

3.2 Cut and muscle analysis

The trial utilised 6 major cuts from 18 carcasses representing an uneven mix of bulls, heifers and steers with one side of each hung by the Achilles tendon (AT) and the other by the aitch bone (TX). The objective was to facilitate evaluation of UK consumer response across a comprehensive quality range and to provide some limited indication of individual cut x hang interactions. All samples were aged for 21 days post slaughter and grilled for serving.

Table 4 defines the muscle tested within each cut with the commercial topside, rump, knuckle and tenderloin cuts each including multiple muscles. The *M.gluteus medius* was divided into two portions along the internal seam.

Table 4. Definition of cut and muscle nomenclature and codes

CUT	MSA Code	Muscle	Common Description	Utilised
Topside	TOP001	M. adductor femoris		
	TOP033	M. gracilis		
	TOP073	**M. semimembranosus**		Tested
Rump	RMP005	M. biceps femoris (syn. gluteobiceps)	Rump cap	
	RMP131	**M. gluteus medius**	Rostbiff (large portion)	Tested
	RMP231	M. gluteus medius	Rostbiff (small portion)	
	RMP087	M. tensor fasciae latae	Tri-Tip	
Knuckle	**KNU066**	**M. rectus femoris**	Bullet	Tested
	KNU098	M. vastus intermedius		
	KNU099	M. vastus lateralis		
	KNU100	M. vastus medialis		
Striploin	**STR045**	**M. longissimus dorsi**		Tested
Featherblade	**OYS036**	**M. infraspinatus**		Tested
Tenderloin	TDR034	M. iliacus		
	TDR062	**M. psoas major**		Tested

A large range of MQ4 was detected by consumers within each muscle tested as illustrated in Figure 5 with all muscles dispersed across at least two quality categories and further by the product means and 95% confidence intervals displayed in Figure 6. In these tables both hang methods are merged to represent the quality range detected by consumers.

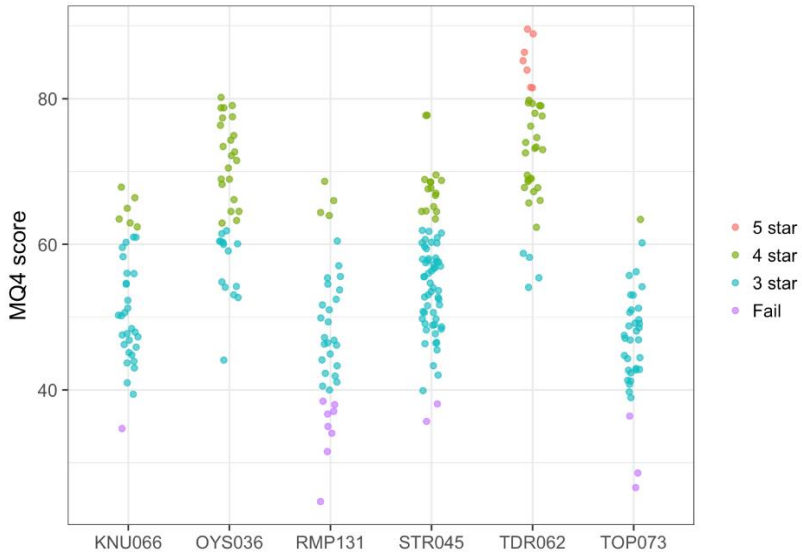


Figure 5. MQ4 score distribution within muscle and related quality categories

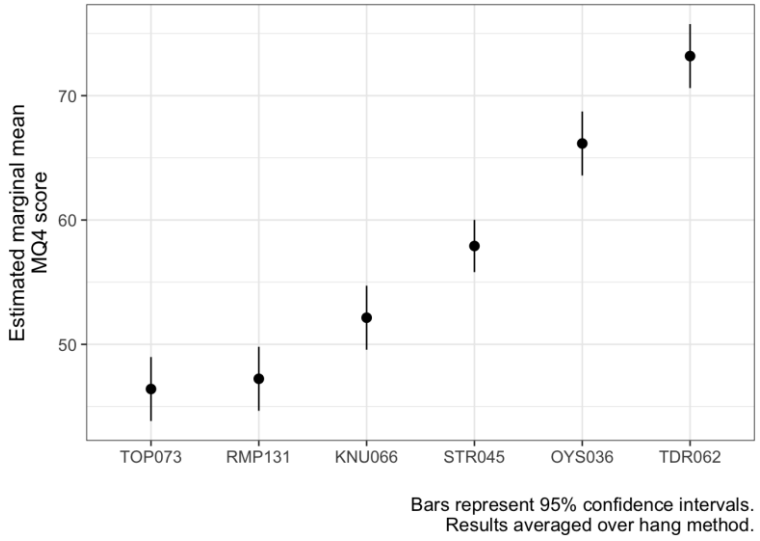


Figure 6. Adjusted MQ4 means and confidence intervals by muscle.

Figures 5 and 6 illustrate that UK consumers readily differentiate quality differences within cut but also that many cuts can have equivalent consumer ratings. This challenges the logic of retail description where the consumer is generally presented with a cut name as the means of meal choice rather than a meal driven outcome. Assuming MQ4 can be predicted with sufficient accuracy a logical but confronting alternative would be to utilise a standard MQ4 band based description across

multiple cuts. Under this scenario Figure 5 could be described as 3*, 4* or 5* grills in line with the cut-off score defined categories and colouring.

3.3 Carcase suspension analysis

While only 18 carcases were included in the study each had a balanced comparison for all cuts with alternating left and right sides AT or TX hung. Figures 7, 8 and 9 provide alternative representations of the impact of AT relative to TX carcase suspension. As shown the effect differed considerably by muscle with the majority of data consistent with previous consumer based studies. The exceptions are the rump being lower relative to topside and striploin and a larger than normal MQ4 reduction for TX tenderloin. Given the low numbers these variations should be viewed with caution.

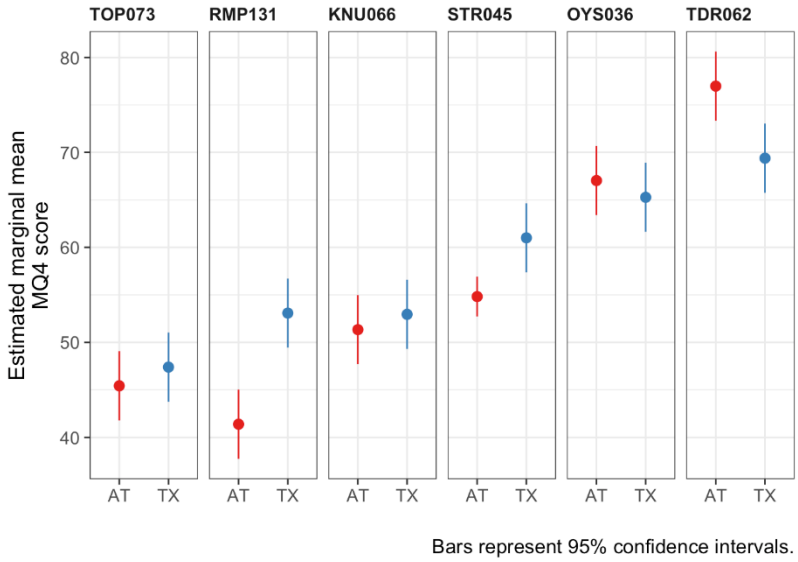


Figure 7. Adjusted means and confidence interval by cut and hanging method

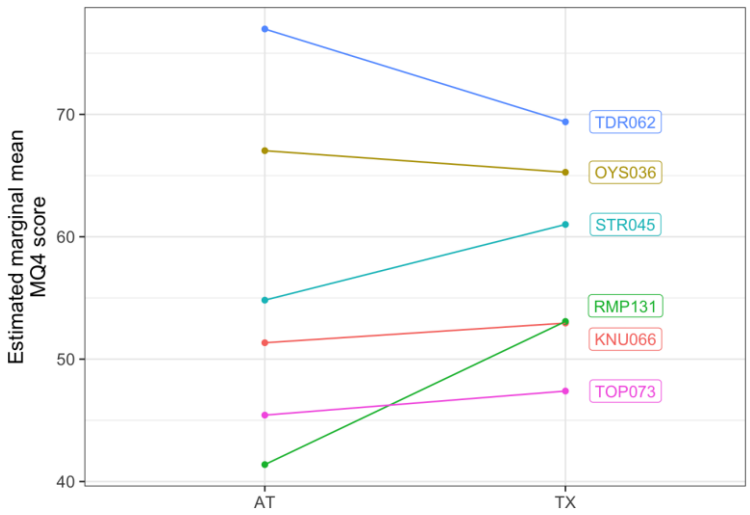


Figure 8. Relative muscle MQ4 score by hanging method

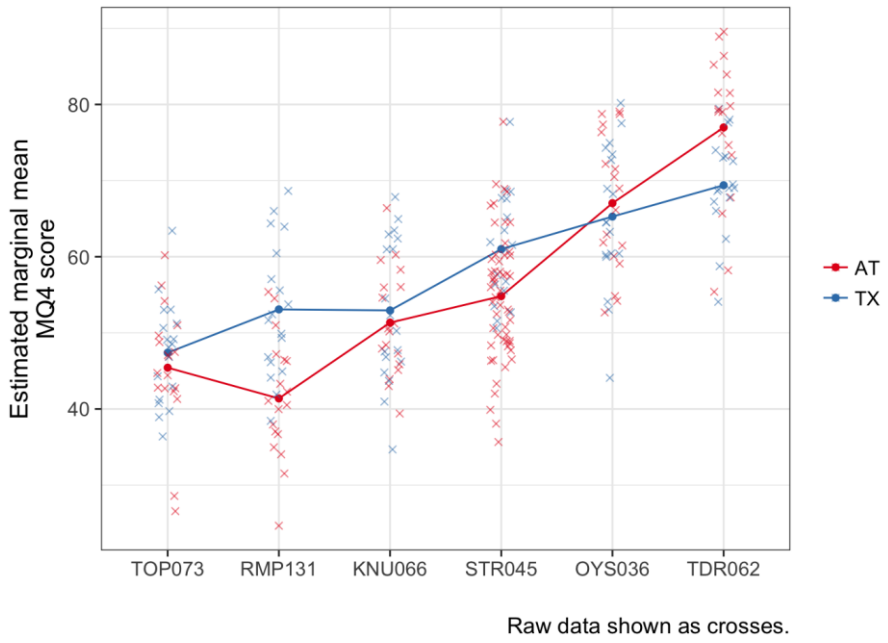


Figure 9. AT and TX MQ4 distribution by muscle and hang method

The muscle and hang estimates are shown in Table 5 with the model including a single term for animal.

Table 5. Muscle and hang effects

ms			
KNU066	-5.038	1.629	These estimates represent deviations of the
OYS036	10.659	1.629	muscle mean from the overall mean.
RMP131	-14.995	1.629	Because the data are balanced, the estimates
STR045	-0.273	1.629	are the same those based on the raw means
TDR062	20.601	1.629	
TOP073	-10.950	1.629	
hng	1.804	1.030	The average TZ-effect (over the six ms) is 1.804
hng*ms			
KNU066	-0.194	2.303	These estimates represent deviations of the hang effect
OYS036	-3.568	2.303	for each muscle from the overall hang effect.
RMP131	9.894	2.303	Thus for TDR the hang effect is 1.804−9.392 = −7.588.
STR045	3.096	2.303	
TDR062	-9.392	2.303	
TOP073	0.164	2.303	

3.4 Sex and further carcase effects

As there were only 18 cattle within this study data are insufficient to generate reliable estimates for animal covariates such as sex, carcase weight and marbling. A simple model however established that animal, muscle and muscle x hang were highly significant (P>0.000) with hang marginal at P=0.082. There is clearly a difference between animals. The analysis aimed to remove the animal effect, as far as possible, to compare the muscle and hang effects as it is assumed that these effects are the same in each animal. The significant muscle, hang and muscle x hang interaction were similar

to those in the MSA model based on considerably more data but from mostly very different cattle types. The low animal numbers restrict the ability to find any significant sex effect but a trend in line with expectation is found with the bulls tending to score in the lower half. The means of these effects are bulls (–1.26) females (0.20) and males (3.39) across all sample observations. This is illustrated in Figure 10 with the calculated animal effect for each animal reported in Figure 11.

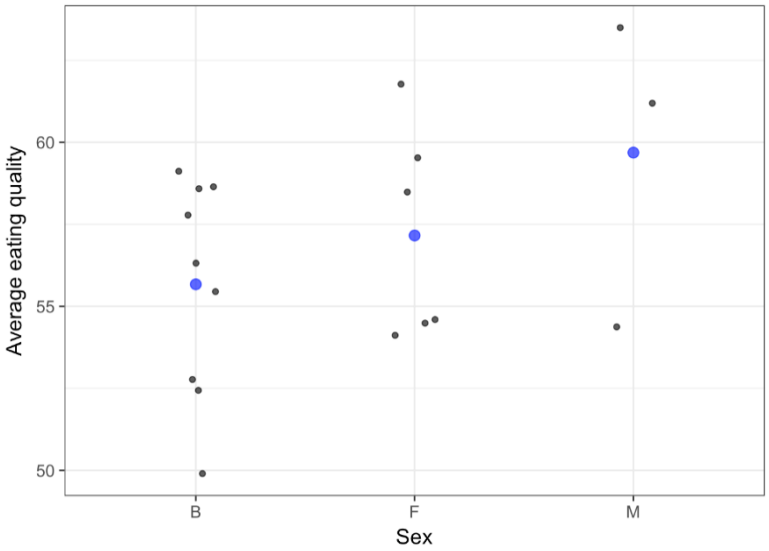


Figure 10. Mean sample (MQ4) values by sex

	sex	an.eff
E5Z5	B	-8.641
T2S3	B	-4.556
A7B8	M	-4.426
D8V8	F	-4.001
Z0G9	B	-3.411
K4D9	B	-2.013
T8Z5	F	-2.002
A1L7	F	-1.487
E9E8	B	0.001
P1W7	B	0.454
C5H6	F	0.514
X0Z1	B	1.251
J8P8	B	2.167
F2G7	F	3.319
P8W2	B	3.374
H4V2	F	4.874
T9D2	M	6.557
J9L1	M	8.026

Figure 11. Estimated Individual animal effects

3.5 EUROP relationships to consumer eating quality ratings

EUROP muscle and fat scores were assigned to all trial carcasses. Trial carcasses ranged from –U to O+ with numbers very low for meaningful analysis. For interest an analysis was conducted to investigate relationships of EUROP ratings to consumer assessed eating quality. The results are illustrated in Figure 12 (Muscle Score) and Figure 13 (Fat Score). As expected and consistent with a larger European study reported by Bonney et al (2016) no eating quality relationship was found to either score.

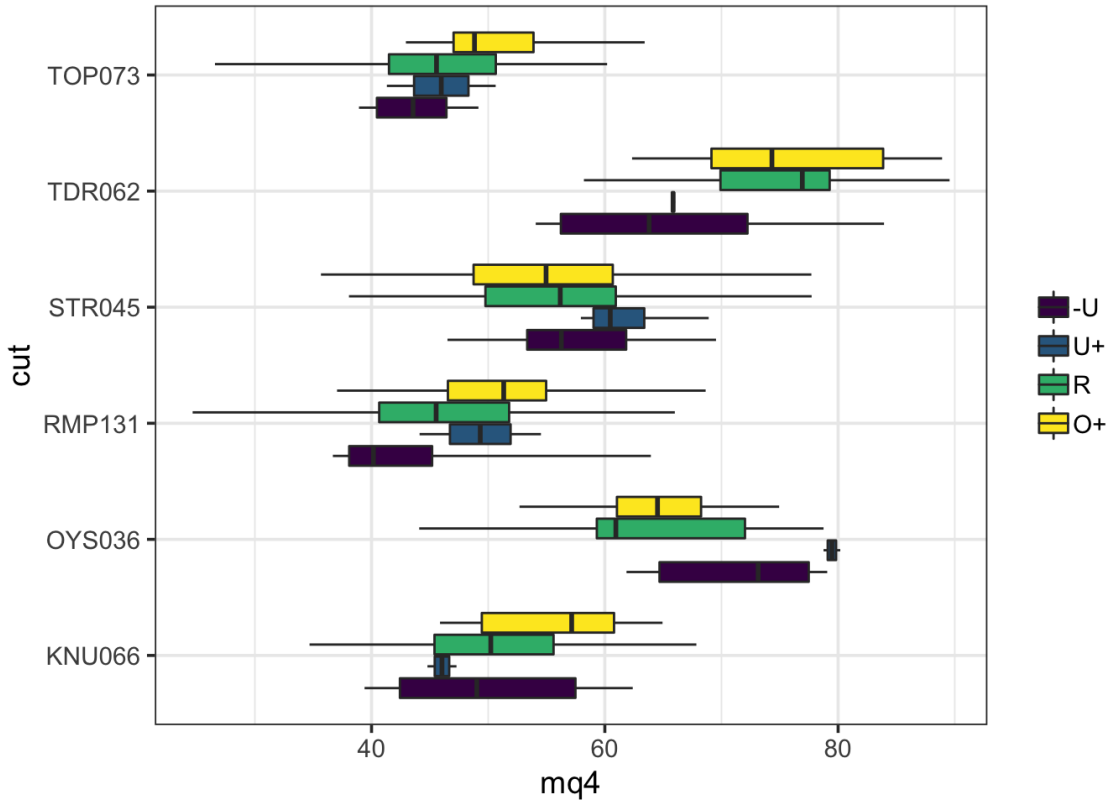


Figure 12. EUROP muscle score relative to eating quality (MQ4) by muscle.

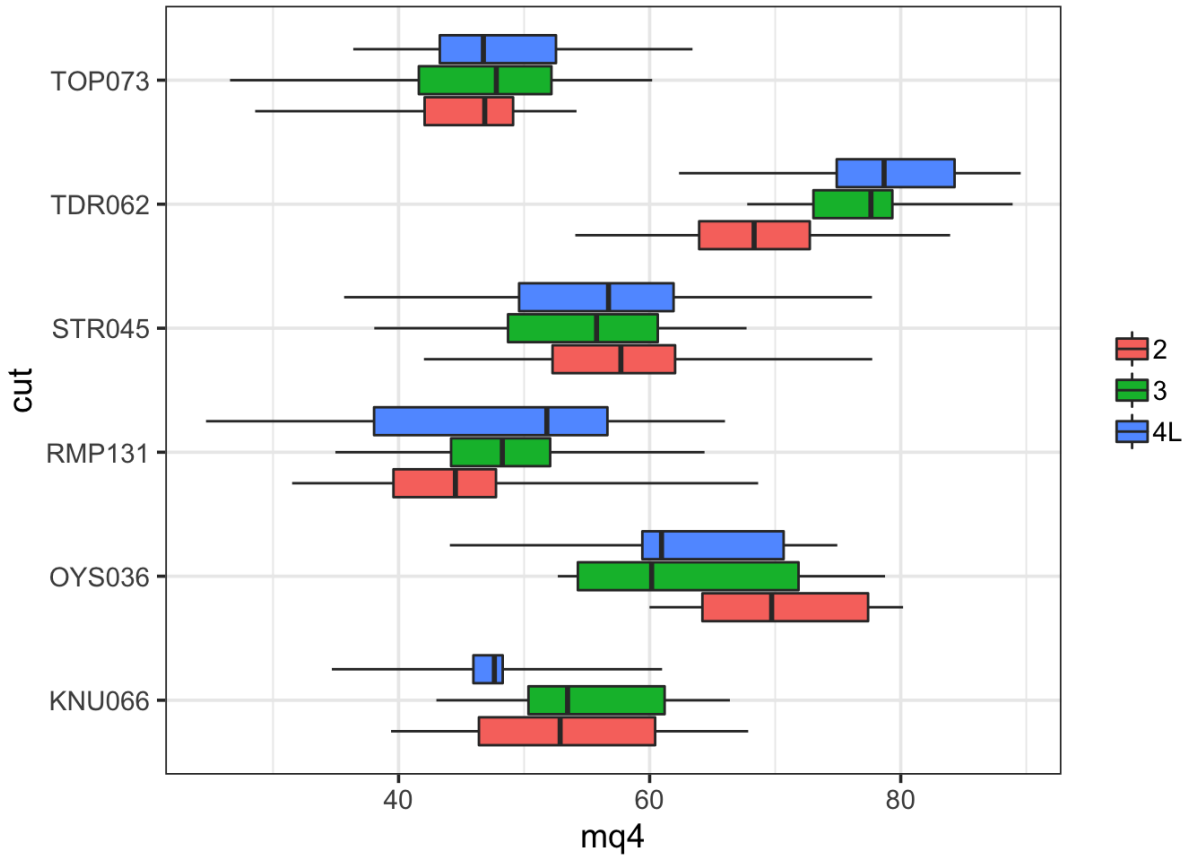


Figure 13. EUROP fat score relative to eating quality (MQ4) by muscle.

4 Conclusions/recommendations

The objective of this project was to facilitate evaluation of UK consumer response across a comprehensive quality range and to provide some limited indication of individual cut x hang interactions.

The results, while from a modest level of data, establish that UK consumers are at least as reactive to eating quality variation as other consumer populations, and perhaps more so. Significant quality variation was also found within the cattle tested and also within each cut indicating that improved segregation, reflecting consumer response, could improve the beef value offer.

An effective prediction model for UK consumers and beef is plausible and supported by initial evaluation utilising existing MSA and related models. Further collaboration with MLA and other partners with an interest in eating quality, combined with further UK testing, could expand existing source data and enable development of an efficient model if desired.

A significant technical objective of great potential industry value could be a combination of SEUROP and a quality prediction model to balance the value of yield and consumer satisfaction. Adoption of this within pricing systems could encourage substantial industry change and consumer alignment.

5 Key messages

Key messages are:

- MSA protocols were used to evaluate 6 cuts derived from Achilles (AT) and Aitch Bone (TX) hung sides of 18 cattle slaughtered in Wales and aged 21 days post mortem. The cattle included 9 young bulls, 6 heifers and 3 steers.
- UK consumers displayed high discrimination in segregating beef quality bands.
- 'Willingness to Pay' data demonstrated substantial value differences in line with quality ratings.
- Clear eating quality differences were identified by consumers between cuts and hang methods.
- Niether EUROP muscle or yield scores were correlated with consumer assessment.
- An effective prediction model for UK consumers and beef is plausible and supported by initial evaluation utilising existing MSA and related models.

6 Bibliography

Bonney, S., Pethick, D., Legrand, I., Wierzbicki, J., Allen, P., Farmer, LJ, Polkinghorne, R., Hocquette, J-F. and Gardner, G. 2016. European conformation and fat scores have no relationship with eating quality. Animal 10:6, 996–1006.

Watson, R., Gee, A., Polkinghorne, R. and Porter, M. 2008. Consumer assessment of eating quality and development of protocols for Meat Standards Australia (MSA) testing. Australian Journal of Experimental Agriculture 48 (11): 1360-1367

7 Appendix

7.1 Protocol amendment for Silesia Velox CG-2 grill and notes regarding consumer label procedure

NOTES RE AHDB GRILL CONSUMER TEST PROCEDURES 17/9/2017

Silesia Velox CG-2 Grill: The Silesia Velox double grill requires some protocol modification to ensure a valid result and critically to maintain failsafe sample ID.

Set Up: To reduce the risk of tripping out power during cooking ensure the two grills are attached to different circuits.

Turn both grills on at least 45 minutes prior to the session starting to ensure they are hot and the circuits are coping.

Settings: 220˚C on both grills.

Loading: The grills need to each cook 5 steaks with great care taken to retain the 3 - 4 -3 layout during loading, cooking and unloading upon which sample ID depends. The following diagrams illustrate the standard MSA protocol for the 3 phase S-143 and S-Tronic 161 Silex grills which cook 10 samples per round and the Silesia Velox with two sets of 5. The number indicates the mandatory order of loading and unloading and related positions.

The loading pattern is particularly critical for the twin grill due to the lid mounting mechanism which can displace the steak positions due to the floating hinge mechanism. (The larger models have a balanced top plate with adjustable weighting which creates less issues as the plate is lowered in a parallel orientation). To maintain ID in the event of some displacement the arrangement shown for the twin grill offers some protection together with providing a flatter surface to position the top plates.

For both grill types avoid placing samples close to the edge of the grill plates where the heating tends to be more variable.

7.2 Consumer questionnaire as utilised for AHDB testing

Date:_____Group Name:_____

I.D. Number :_____ Session Number_____

Thank you for your participation today with our meat tasting.

Before you commence please listen to the instructions on how to use the scales contained in this questionnaire.

In between each sample please cleanse your palate by first taking a sip of diluted Apple Juice then chew a piece of bread and then take another sip of diluted Apple Juice

We are after your opinion and therefore ask that you do not talk to any one else in the room during the research session.

Now just a few questions about yourself, please tick the appropriate box. (All this information is strictly confidential)

Demographic data

1) Please write down the county of the address you normally live at:_____

2) Age group (please tick 1 box)

Younger than 20 years	20-25 years	26-30 years	31-39 years	40-60 years	Older than 60 years
☐	☐	☐	☐	☐	☐

3) Gender (please tick 1 box)

Male ☐ **Female** ☐

4) What is the occupation of the main income earner in your household? (please tick 1 box)

Trades	Profession eg. Teacher	Admin	Technical	Sales/ service	Labourer	Home duties	Student	Other employment	Not employed
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

5) How often do you eat Beef? (in any form such as Steaks, Roasts, Stews, Casseroles, Mince, BBQ, etc., please tick 1 box)

Daily	4-5 times a week	2-3 times a week	Weekly	Fortnightly	Monthly	Never eat
☐	☐	☐	☐	☐	☐	☐

6) How many people normally live in your household? (Adults are aged 18 years and over)

	1	2	3	4	5	6	7	8 or more
Adults	☐	☐	☐	☐	☐	☐	☐	☐
Children	☐	☐	☐	☐	☐	☐	☐	☐

7) Please read the following statements and tick the <u>one statement</u> that applies to you

☐ **I enjoy red meat. It's an important part of my diet**

☐ **I like red meat well enough. It's a regular part of my diet**

☐ **I do eat some red meat although, truthfully it wouldn't worry me if I didn't**

☐ **I rarely / never eat red meat**

8) When you eat beef, such as steaks, what level of cooking do you prefer? (please tick 1 box)

Blue ☐ **Rare** ☐ **Medium/Rare** ☐

Medium ☐ **Medium/Well Done** ☐ **Well Done** ☐

9) What level of income best categorises your <u>combined household income</u>? (please tick 1 box)

Less than £25,000 per year	£25,001 to £50,000 per year	£50,001 to £75,000 per year	£75,001 to £100,000 per year	£100,001 to £125,000 per year	£125,001 to £150,000 per year	More than £150,000 per year
☐	☐	☐	☐	☐	☐	☐

10) What level of education have you reached? (please tick 1 box indicating the highest education level achieved)

Did not complete high school	Completed high school	College/ A Levels	University graduate
☐	☐	☐	☐

11) What is your cultural heritage? (please tick 1 box)

British decent	Australian decent	European descent	Asian descent	Other	Prefer not to say
☐	☐	☐	☐	☐	☐

If other please specify _____

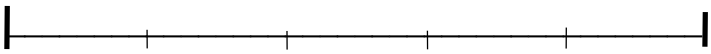
All information collected in this survey is strictly confidential.

Product response sheet:

Please note that while there are 7 identical sheets to be completed, only 1 exmaple has been included below.

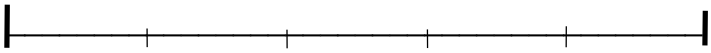
PRODUCT :

Tenderness



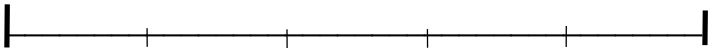
Not Tender — Very Tender

Juiciness



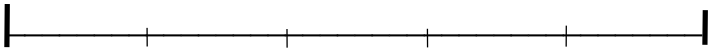
Not Juicy — Very Juicy

Liking of flavour



Dislike Extremely — Like Extremely

Overall Liking



Dislike Extremely — Like Extremely

Please tick ☑ one of the following to rate the quality of the beef sample you have just eaten

Choose **one** only (you must make a choice).

- Unsatisfactory ☐
- Good everyday quality ☐
- Better than everyday quality ☐
- Premium quality ☐

Willingness to Pay Sheet:

Based on the beef you just consumed: Please mark the line at the price per Kg you believe best reflects the value for each category.

Unsatisfactory Quality

£0/kg £5/kg £10/kg £15/kg £20/kg £25/kg £30/kg £35/kg £40/kg

Good Everyday Quality

£0/kg £5/kg £10/kg £15/kg £20/kg £25/kg £30/kg £35/kg £40/kg

Better than Everyday Quality

£0/kg £5/kg £10/kg £15/kg £20/kg £25/kg £30/kg £35/kg £40/kg

Premium Quality

£0/kg £5/kg £10/kg £15/kg £20/kg £25/kg £30/kg £35/kg £40/kg

Are you the regular purchaser of beef for your family (please tick one box)?

Yes ☐ No ☐