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Consumer Sensory Perception of Lamb and Sheepmeat

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Consumer Sensory Perception of Lamb & Sheepmeat

1.0 Executive Summary

This Trial was conducted to explore issues associated with consumer sensory perception of Lamb and Sheepmeat. Key questions related to the degree of consumer satisfaction across the range of Sheepmeat available, to the sensory factors which contributed to that satisfaction and the feasibility of creating a consumer standards based grading system.

The results demonstrate that consumers do have a consistent view relating to Lamb and Sheepmeat eating quality, which can be estimated by weighting principal sensory variables. A score, calculated by combining consumer Tender, Flavour liking, Juiciness and Overall satisfaction scores, has been derived statistically. This has been designated CSEQ, an abbreviation for Clipped Sheepmeat Eating Quality.

The CSEQ score provides a good fit against the results obtained from testing 360 Sydney consumers. Each consumer tested seven Lamb or Sheepmeat samples with 180 consumers served grilled product and 180 roast product. A very detailed sensory Protocol was developed which ensured a full range of samples were provided to each consumer and that variables were either reduced or balanced to ensure a reliable result.

Optimum CSEQ scores were also derived to define the division points between Unsatisfactory and three further quality grades ranging from 'Good Everyday Quality' to 'Premium'.

A large amount of production information was recorded for each cut tested with all data stored in specially created electronic databases. These may form a base from which to add data generated by future Trials. All Protocols developed for this Trial are well documented and provided to assist in future development.

Several problems relating to the sheep supplied restricted analysis opportunities as to the 'cause and effect' issues in relation to eating quality although such analysis would in any event have been limited on a sample of 120 sheep.

The data is sufficient however to confidently state that a satisfactory Prediction Model could be developed to estimate CSEQ across cooking methods and cuts from a wide range of carcasses. To achieve this objective considerably more product would need to be tested to create sufficient analytical depth across all muscles, sheep types, cooking methods and processing treatments.

Such a model would provide a unique basis from which to guarantee a consistent and reliable product to consumers.

The traditional testing approach of objective measurement was also evaluated on a subset of product. There was a negative relationship between objective peak force and sensory dimensions, although the accuracy was not sufficient to be useful to predict sensory outcomes. Given that a large portion of the sensory score relates to flavour rather than tenderness it is perhaps not surprising that the results are not convincing as a consumer surrogate.

The data generated from the trial is provided in electronic format. The Appendix contains Attachments which define the database formats in detail.

A large number of recommendations are also made to facilitate planning, management and execution of future work.

An important recommendation is that any future Trial program be developed and managed by a specialist Sheep industry team with a combination of extensive industry experience and scientific expertise.

2.0 Recommendations

The recommendations presented below arise from experience in this Trial and are discussed in greater detail throughout the body of the report.

♦ Establishment of Consumer Based Eating Quality Grading.

It is recommended that:

1. The sheep eating quality score (CSEQ) be adopted as the measure of predicted consumer perception of eating quality.

2. The CSEQ score for a cut be calculated from the clipped scores of ten consumers by applying the following calculation –

   CSEQ = Tenderness x 0.2
   + Juiciness x 0.1
   + Flavour x 0.3
   + Overall x 0.4

3. It be noted that the most accurate CSEQ score grade division points are 44 to separate Unsatisfactory from Good Everyday Quality (3 Star), 65 to divide Good Everyday Quality from Better than Everyday Quality (4 star) and 80 to further divide Premium (5 star) Quality.

4. The minimum score for Good Everyday quality be further considered formally to assess the balance desired between accurate sample allocation and level of consumer guarantee.

5. The potential to establish a Prediction Model able to calculate individual cut by cooking method CSEQ estimates be noted.

6. Considerably more data would be required to enable a valid Prediction Model to be developed.

♦ Sensory Testing Procedures

It is recommended that

7. Direct consumer testing be adopted as the most accurate form of quality assessment.

8. The Consumer Testing Protocols developed continue to be rigorously applied in future work.

9. Four sensory scales – Tenderness, Juiciness, Liking of Flavour and Overall Liking be used as the basis for sensory scoring.

10. The possibility and accuracy implication of utilising fewer than ten consumers (possibly six) per sample be evaluated over additional consumer groups.

11. For maximum efficiency internal MLA agreement be sought to co-ordinate Beef and Sheepmeat consumer evaluation activities.

12. Ticketing and data control software driven systems, sample preparation arrangements and cooking and serving equipment be jointly used by Beef and Sheepmeat programs .

♦ Database Management

It is recommended that:

13. A consolidated database structure be adopted which accumulates data from all Lamb and Sheepmeat Trials incorporating sensory evaluation.

14. The database structures and content established for this Trial be reviewed and modified where desired by a dedicated sheep industry team.

15. The SEQRef unique sample identification basis be adopted and that all reference numbers be assigned from a central electronic system which eliminates any possible duplication.

16. Standard column orders and field formats be agreed for all data input sections.

17. Formats be adopted which are directly compatible with principle statistical software packages.

18. Procedure be agreed regarding linkage of sensory scores to single test products created by the amalgamation of cuts, typically from left and right carcass sides.

19. Once the above issues are agreed as many database control functions as possible be automated. These include data duplication and calculation within individual databases and transfer of data between databases.

20. The procedures, formats and standards be fully documented and adopted as Protocol for all Trial work.

♦ Preparation of Consumer Test Samples

It is recommended that:

21. Strict Protocols be adopted for the handling, ageing, preparation, ticketing, freezing and thawing of consumer test samples.

22. The Protocols developed for this Trial form a basis to be added to or modified over time by a specialist technical group.

23. Standard format ticketing be allocated from a central electronic system for all product identification purposes. This must ensure unique coding and link to database input systems.

24. An ageing standard be agreed and applied to all samples other than those specifically collected to evaluate ageing effects.

25. All consumer samples be prepared from chilled cuts prior to freezing.

26. The minimum possible sample preparation be conducted at abattoirs, with sample fabrication activities centralised to a specialised facility with attendant specialist personnel.

27. The implications of central preparation coupled with ageing standards be noted with particular reference to consequent transport arrangements.

28. Should preparation at abattoirs be adopted the need for a single group of specialist skilled staff and appropriate support equipment be noted.

29. The restrictions on individual muscle testing arising from cut size in relation to required samples be noted.

30. The possibility of testing cuts rather than component muscles be considered.

31. The option of testing smaller muscles by taking the muscle from multiple similar carcasses and then grouping them as a single consumer sample be further considered.

32. Alternatives to butchers twine be evaluated for accumulating portions of material to be grilled.

♦ Slaughter and Boning Room Procedures at Abattoirs

It is recommended that:

33. The total number of sheep slaughtered and cuts programmed for collection on any one day be carefully considered in the design phase to ensure Trial Protocols can be fully maintained.

34. Specialist staff resourcing is adequate to ensure Protocols are followed explicitly.

35. Sheep eartags be physically retained in kill order, with procedures to accommodate multiple and missing tags by animal.

36. The tags be matched to carcass number and to source livestock documentation prior to disposal.

37. Ticketing of cuts be only via pre allocated unique tickets generated from a central electronic database. The tickets applied must be reliably linked to the abattoir carcass number and any eartags.

38. Arrangements for refrigeration and freight of collected samples be explicit, in hardcopy form and be followed up by a designated responsible person.

♦ Sheep Acquisition

It is recommended that:

39. There be clear written confirmation of specifications and delivery requirements prior to kill scheduling.

40. Sheep data availability is verified prior to proceeding with the Trial if the data is of central importance.

41. The format of sheep identification within a consignment is advised prior to slaughter to facilitate accurate transposition.

42. Mustering, loading and transport times and conditions are recorded for all Trial groups.

43. The sheep liveweight required be carefully considered in relation to the desired samples to be collected for consumer or objective testing.

44. Sheep acquisition be planned and agreed by a specialist sheep industry team actively involved in planning the sensory program and setting its' goals.

♦ Objective Testing

Its is recommended that;

45. An agreed ageing regime be established and the linkage of that to consumer testing Protocols also be considered.

46. The conflict between consumer and objective test sample provision due to cut size be noted.

♦ Management

It is recommended that;

47. A specialist team with extensive 'hands on' industry experience and scientific expertise be formed to plan and manage any future program with responsibility for co-ordinating all Trial activity.

3.0 Trial Objectives

The objectives of the project were defined as:

1. To define the key consumer eating quality attributes of Lamb, Hogget and Mutton, particularly defining the relative importance to consumers of Tenderness, Flavour, Juiciness and Overall Liking.

2. To recommend a consumer scoring system and sample preparation Protocol that could provide a base to define grades of Sheepmeat and to relate all production factors to the eating quality result.

3. To identify relationships between consumer perception of eating quality and a range of objective measurements.

In addition it was planned to evaluate tentative relationships between eating quality and a range of animal, slaughter and carcass measurements.

4.0 Trial Conduct and Methodology

4.1 Sheep Acquisition and Transport

In line with the Trial objectives it was important that sheep and cuts used for consumer testing produced a wide range of product quality. This was achieved by utilising Lambs, Hoggets and ewes and a range of cuts in conjunction with two carcass hanging techniques.

To maximise the value of the sensory results it was also desirable to utilise sheep with detailed history to enable preliminary evaluation of factors which either directly impacted eating quality or assisted in its' estimation. Information of potential value included age, breed and growth history.

SARDI (South Australian Research and Development Institute) indicated that they could provide a range of sheep that would meet the Trial requirements for age, breed and growth range. It was advised that all sheep had complete detailed growth and breeding records available for analysis.

Following discussions it was agreed to purchase 120 sheep comprising 40 ewes, 40 Lambs and 40 Hoggets for the Trial. Agreed specifications were for second cross Lambs (Dorset Horn x Border Leicester merino) and merino Hoggets and ewes with carcass weights above 20Kg. The sheep were to be yarded and trucked the afternoon prior to slaughter.

In practice the sheep delivered varied from the agreed specification in breed, weight and records available. The agreed trucking procedures were also not observed resulting in transport on a Saturday versus Sunday and a consequent additional day in lairage. The anomalies created a number of further changes in Trial practice relative to the original design.

Issues Arising from Sheep Acquisition

- This Trial emphasised the importance of clear agreement and follow through in sheep acquisition.

  Despite earlier advice only 42 Lambs had complete records available. These were further reduced to 33 effective records due to unresolved discrepancies between eartag numbers. Consequently very little detailed growth data is available for analysis. If all sheep had full data available however the quantity would still be grossly inadequate for any conclusive analysis relating eating quality to growth patterns or breeds.

- The lower than specified carcass weights also created problems in acquiring a sufficient quantity of product for consumer and objective testing. Twenty-two carcasses from the 120 sheep slaughtered were not boned due to their inadequate size and a number of the remainder were extremely marginal.

- Planning issues will be even more pronounced in commercial acquisitions and need to be addressed. Where production history is required all involved need a clear understanding of precisely what is available and any limitations. Where this data is considered a prime Trial requirement its' veracity and availability needs to be verified prior to despatch of the sheep.

- It is also likely that the period from mustering to slaughter will prove to have a substantial effect on ultimate eating quality. For this reason it is proposed that the database contain provision to record feed, mustering, transport and lairage time information plus climatic conditions.

- There will often be a conflict between minimal cost, particularly in transport, and the number of carcasses or cuts that can be effectively monitored or collected for research purposes on a single day.

  Where cost minimisation requires unsatisfactory lairage handling times or an excessively optimistic collection regime it is recommended that scientific accuracy take precedence. The cost of subsequent product preparation and tasting will substantially exceed the cost of product and is insignificant relative to the risk of a compromised research result.

4.2 Slaughter

Arrangements for slaughter and boning were made through VIAS with the Meat Industry Training Centre. 59 Sheep were slaughtered on Monday June 7th and 61 on Wednesday June 9th. The Monday slaughter group was held in lairage with access to water only from arrival on Saturday June 5th, the day of trucking from Struan.

The second group was held on pasture from Saturday until Tuesday morning.

Eartags were recorded at slaughter by abattoir staff and alternate carcasses were Tenderstretched and Achilles hung. Stun time was individually recorded. No electrical input was used on the slaughter floor. A series of pH readings were taken in the chiller prior to rigor mortis. Each pH reading was accompanied by temperature and time data with up to eight readings per carcass taken, the majority having six readings recorded.

An ultimate pH reading was taken on the following morning, prior to boning. Hot carcass weight was recorded on the slaughter floor with a high percentage of carcasses also weighed cold prior to boning to record actual shrinkage. Dentition was not recorded on the slaughter floor but a large number of the Lambs and Hoggets were mouthed in lairage, with all having milk teeth only.

Carcasses were cut and 'opened up' at the midline to allow use of a VIA (Video image Analysis) unit. The VIA unit recorded a cross-sectional image of each carcass to allow later image processing to obtain fat and muscle data.

Issues Arising from Slaughtering

- The slaughter data collected again reinforces the need for strong Protocols and dedicated experienced staff involvement at all points of data collection.

  Despite a very co-operative abattoir and staff the slaughter data proved deficient in two areas: accurate eartag transcription and recording of dentition.

- It is recommended that in future eartags be physically removed from each carcass and threaded onto a wire in chain order to allow later checking/verification. Missing tags and multiple tags, from one or both ears, must also be accurately related by the system used.

- In this Trial approximately 10% of tags were incorrectly recorded, mostly by numbers being transcribed out of sequence; 239 versus 293 for example. Further difficulties were created by duplicate numbers within the various groups and colour and number combinations.

  To assist in prevention of this type of problem it is recommended that the details of any identification system be established prior to sheep delivery, where possible.

4.3 Boning and Cut Collection

Boning of each group was conducted on the day following slaughter. The lighter than agreed carcass weights created an immediate challenge to the Trial design due to cut size being incompatible with the volume of material required for consumer and objective testing.

After consultation with Dr John Thompson and Alan Gee, both of whom were on site, it was decided to discard the 22 carcasses with a weight below 20kg. These were sold to a local wholesaler.

The remaining carcasses were broken down into major commercial cuts as follows:

- Backstrap
  (Hind Quarter portion of left side and entire right hand Backstrap)
- Fore Quarter Loin Portion
  (Anterior portion of left side Backstrap)
- Topside
- Silverside
- D Rump
- Bolar Blade
- Brisket
- 'FQ Scrap'

The 'FQ Scrap' was composed of the blade muscles of the spare side and was collected to allow a larger block for roasting. A total of 1441 cuts were collected.

Procedures within the boning room were established to ensure each cut was accurately identified. Cuts from each carcass side were firstly placed on separate trays as boned. Pre assigned, laminated, numbered tickets were then applied to each cut. Each cut, with its allocated ticket, was then individually bagged and vacuum packed.

Vacuum-packed cuts were held in a chiller at 0 - 4° C until the days' production was complete. All cuts were then transferred to a freezer in the evening. This provided approximately 36 hours ageing from slaughter to commencement of freezing. The cuts were laid out to ensure rapid freezing.

Following freezing all cuts were inventoried, checked, sorted into cut types, then boxed, strapped and transported to Sydney in frozen form.

Issues Arising from Boning and Cut Preparation

- The cuts were boned in standard commercial form. This differs from the ultimate sample required for consumer testing. To prepare the consumer sample the epimysium is removed and a standard size 'block' is prepared following very specific Protocols for position within the cut, fibre orientation etc.

  This is a long step beyond commercial fabrication and requires skilled personnel. For this Trial it was desired to restrict ageing to two days which imposed severe limits on timing between boning and product preparation for consumer testing. It was elected to freeze the primals and then to thaw immediately prior to consumer testing at which time the consumer preparation could be done. This created practical difficulties resulting in variation in total ageing time and a reduction in product available for objective testing.

  For future Trials it is recommended that all samples be fully prepared for consumer testing prior to freezing, rather than prepared after thawing.

  This carries some implications for collection practice depending on the desired ageing time.

- The most efficient process is generally to attempt the minimum work at the abattoir and conduct all consumer preparation at a specialist single site with experienced staff. This requires transport of chilled carcasses or primals. By commercial transport the minimum practical period between kill and prepared product for freezing is 5 days.

If ageing of less than 5 days is required airfreight or dedicated transport arrangements would be required to utilise a central preparation location. This issue of an ageing standard also needs agreement as it will have significant flow on costing effects.

- The alternative of fully preparing consumer samples at the point of slaughter might also be possible but only at a much reduced number of locations. This approach would require transport of staff to conduct the cut up, specialised packaging and ticketing materials and suitable freezing facilities. Either option will add to cost.

4.4 Consumer Sample Preparation

The frozen, primal cuts were trucked to a boning room in Naremburn, a Sydney suburb, for storage and conversion to consumer test samples. The boning room is leased by Cosign Pty Ltd and utilised for the preparation of consumer samples for the MSA program. The staff is skilled in this form of work and accustomed to separating individual muscles then further preparing them into standard forms for sensory testing.

All MSA procedures are defined in rigid Protocols which stipulate removal of epimysium, orientation of grain, block sizes and all other aspects of preparation including ticketing, freezing and storage.

The proven MSA procedures were adapted for the sheep Trials to provide a sound base. The major, and in retrospect unsatisfactory, divergence from MSA procedures was the use of frozen primals, thawed and fabricated into consumer samples as required, rather than preparing the consumer samples prior to freezing.

The approach Trialled, of thawing and preparing from frozen product, is regarded as unsatisfactory for future work as the time to prepare is difficult to estimate and the juggle between ageing to a common time, thawing correctly and being 'just in time' for the sensory test is impractical. The better alternative is to prepare fully prior to freezing. Where transport time is too long this may necessitate preparation at or close to abattoir if two-day ageing is considered necessary. From experience 5 days is about as short a period as can be managed from a central location.

Only Backstrap, Rump, Silverside and Topside were consumer tested in this Trial. The remaining cuts collected have been retained to provide linkage to any later consumer studies or for objective testing. Only the cuts utilised have been thawed and processed into consumer samples.

Protocols for consumer sample preparation were developed utilising some test carcasses of light, medium and heavy weights prior to preparing the actual test product.

In the case of the Backstrap the anterior portion of one Backstrap was packed separately, labelled FQ loin, and retained frozen for objective testing. The full length of the second Backstrap plus the posterior portion of the first were utilised in the consumer samples.

A further difficulty with the preparation from frozen approach was that of estimating the time required accurately. Freezing time and ageing can be varied to accommodate preparation delays or time overruns when preparing from fresh product. The same flexibility is not possible when preparing from frozen. As the time of consumer testing is fixed thawing time must be set to accommodate a 'worst case' preparation expectation. This is not a great problem for roasts as the 'block' of meat is relatively easy to fabricate and the entire roast is cooked and eaten on a single night.

The situation is worse for grilling samples however as the preparation is far more complex and the product from a single loin is tested over multiple nights. When prepared fresh and frozen in prepared consumer from the individual samples required for a specific night can be thawed as required. In the frozen primal form all nights are of necessity thawed together which creates a variation in product ageing across the test period.

Detailed description of sample preparation is outlined in a document entitled 'Sensory Testing of Lamb & Sheepmeat Protocols' which is presented as Attachment 1 in the Appendix.

In brief however, the Backstraps were reduced to the primary longissimus muscle by removing side muscles, fat and epimysium. The test muscle was then sliced into 15mm long segments across the grain. Due to the very small diameter of many of these portions they were assembled by grouping multiple pieces, from the one muscle, and bound together with butcher's twine. This enabled the material to be handled as a piece for cooking. Holding the material in this form meant that no compressive packing or squeezing took place while providing a reasonable size portion for consumer sampling. The smallest size allowable was dictated by this requirement whereas the upper limit was defined by the need to cook ten samples simultaneously on the 'SILEX"' clamshell cooker.

Prior to serving the twine was removed and the then semi-fused piece divided into two for consumer testing. A similar procedure was adopted for grill samples from the Rumps. The cap muscle was removed and the grain directions followed in fabricating the 15mm slices for twining.

The Silversides and Topsides were also first reduced to single primary muscles. The muscles from both carcass sides were then faced together to create a block approximately 150mm by 75mm by 75mm. The prepared sample was then passed down a chute and netted to maintain it as a single 'block' for roasting.

The block size is important to provide reasonably consistent cooking time, to ensure adequate product for ten consumers and to provide sufficient material to hold temperature over the period from cooking to serving the last consumer round.

The serving process required approximately 40 minutes. Using a block of the designated size and holding in lidded bain-maries maintained the temperature within 1°C to 2°C for the entire period. This allowed for serving in each of the six presentational positions without temperature bias.

The fully prepared grill and roast samples were individually vacuum packed following preparation with a unique alphanumeric coded ticket enclosed in each pack.

Samples were then sorted into the required cooking and serving order by session and stored at 1°C until transfer to the test venue.

Ticketing

Unique ticketing is a critical element in Trial design and becomes more complex where data is assembled over a period of time and from multiple Trials. Identifiers such as carcass number are duplicated daily within abattoirs, as are most eartags. These forms of identification also lose uniqueness once multiple cuts are taken from a single carcass.

To ensure all consumer samples had unique identification a ticketing database system, primarily used for MSA samples, was created. 67,600 codes beginning with AA00 and ending in ZZ99, plus another 67,600 beginning Z99Z and a further 67,600 from OOAA to 99ZZ were created to establish the database. Each of these sets were then randomly distributed by arraying them in 26 columns of 2600 codes and then applying random re-ordering across both axes at least ten times.

This system provided a sequence of codes in which there were categorically no duplicates and no trace of creation order or sequence. The ticketing database was linked directly to the pick software providing for electronic control of ticketing from printing of sample identification tickets to production of plate and questionnaire stickers. Ticket printing files were emailed to Sensory Solutions to produce the plate and questionnaire stickers. The same system also controlled the printing of ovenproof tickets used to maintain roast identity during cooking.

Issues Arising from Sample Preparation

- The frozen primal approach was adopted in an effort to restrict ageing to two days without incurring additional costing either in specialist transport or in moving key staff to Werribee. In practise working from the frozen primal created some new difficulties.

  A principal one was the need to thaw to obtain a detailed appreciation of preparation possibilities. In fresh form product preparation can be tailored to suit the precise shape and size of an individual cut to maximise the samples obtained. This is not possible in the frozen cut and its' exact shape, grain layout and so on cannot be determined until thawed.

  This compounded the problem of size with the lighter sheep carcasses where the cuts required maximum utilisation to obtain the required number of samples. To obtain sufficient material cuts from both carcass sides were utilised. This eliminated the possibility of objective testing Rumps, Silversides and Topside as once thawed any material left over from the consumer samples could not be re-frozen for objective testing.

- Cut size is also an issue, with Lambs in particular, that may restrict or prohibit testing of smaller muscles. A reduction in the number of consumers per carcass would assist in this regard although involves some trade-off in accuracy for the individual carcass.

In practice it should be possible to establish a 'generic' relationship between muscles by testing the same muscle from a group of very similar carcasses as if they were derived from a single carcass. The relationship between two or more muscles may then be established by comparing their amalgamated results.

Where a different larger target muscle, of sufficient size to test on an individual carcass basis, is included in the sensory test the relationship within carcass to the smaller grouped muscles may be estimated statistically.

- A further issue is the testing of cuts versus individual component muscles. This has been rejected to date due to the additional variation introduced by testing different muscles without differentiation. Cuts are what are commercially sold however and their testing as such may be a viable approach particularly where this allows sufficient size to test individual carcasses.

- The use of butchers twine to combine small muscle pieces into appropriate size test samples was very successful in product terms. The tendency for the individual pieces to fuse during cooking further added to the effect of the initial grouping.

  The approach is however time consuming and alternatives using stainless steel bands or protein binding materials are proposed for future use if significant volume is envisaged. The stainless band system was not used in this Trial due to the initial capital outlay required, coupled with the desire to fully test the grouping concept first. For continuous testing however the capital cost would be rapidly recouped from labour savings.

  The other possibility is to use one of the protein bonding materials available commercially but this would require testing to ensure there were no associated structural or flavour changes which could impact on the sensory perception.

- It is recommended that the computerised ticket allocation system be adopted for any future work. Unique identification is critical for the success of the program and automation of the process eliminates a number of potentially high risk areas.

4.5 Consumer Sensory Testing

The procedures used for sensory testing were largely common to those for the MSA beef program. Use of MSA procedures, sub contractors, ticketing, software and equipment enabled substantial savings to be achieved together with a more professional service than could be achieved for a 'one off' test.

The Protocols used allocated each cut to ten consumers with procedures to ensure that the samples were spread across groups of consumers and across presentational order to balance out any potential bias.

Consumer Recruitment and Test Procedures

The consumer testing activity was conducted by Sensory Solutions, a Sydney based company, who also conduct MSA beef testing. The beef format was essentially used for Sheepmeat with minimal modification required.

Consumers were recruited by Sensory Solutions predominantly via fund raising arrangements for various community groups. The group, typically a school or sporting club, is paid a fee to organise the distribution of screening questionnaires and co-ordinate the arrangements to ensure the required number of consumers are present at the designated test time and place. Test locations are selected to be as convenient as practical within the constraints of facility requirements. These include a suitable standard environment and kitchen facilities suitable for the test equipment.

Consumers were screened to recruit only those who regularly ate Lamb (at least once a week), were between 20 and 50 and preferred it cooked medium. Each group included both sexes and a range of demographic profiles.

Nine groups of 20 consumers participated in the grill testing. Three groups were used on each of three nights. The locations used were:

- Charts Function Centre, Gosford
- Balgowlah RSL
- Joan Sutherland Centre, Penrith

Roast testing was also spread over three nights with groups of 60 consumers on each night. The locations were

- Wyong Council Chambers
- Penrith Raceway
- Panania East Hills RSL

The consumers were seated in numbered places to allow linkage of all scores to individuals and to ensure the correct product was served in the designated order. The groups were briefed on the questionnaire and scoring system at the commencement of each session.

Each consumer completed a general questionnaire which recorded demographic data and then a separate score sheet for each of the seven samples served. Each score sheet was designated by a four digit alpha/numeric code. Consumers were asked to check the number on the plate carrying each of their samples. These integrity checks directly followed the MSA procedures. A copy of the Questionnaire and score-sheet is enclosed as Attachment 2 in the Appendix.

The standard score sheet carried four 100mm line scales used to record Tenderness, Juiciness, Flavour and Overall Liking, as for MSA beef testing. For Sheepmeat testing there was some concern as to whether Flavour Liking would provide an adequate description. To test this a fifth scale, Flavour Strength, was added to half the score sheets. Adding the scale to half the samples provided a statistical base to compare results on a four and five scale basis. It also allowed any interactions between the two flavour scales to be examined and compared to the single scale results. This eliminated the risk of the flavour liking score being impacted by interaction with flavour strength.

In addition to marking the four or five line scales consumers placed a tick in one of four boxes to indicate the general rating of the sample. Category choices were:

- Unsatisfactory
- Good everyday
- Better than everyday
- Premium

The consumer then initialled each sheet to ensure traceback ability if required.

Sample Presentation Protocols

There are a number of issues which can potentially have a biasing effect on sensory testing. The order in which a sample is served, the relative merit of a preceding sample, the group of people, the night of testing, the range of quality provided and the initial starting point of the first sample (which tends to anchor those following) are all examples. In addition socio-economic differences or any variation in the consumer preferred degree of doneness, and that provided, sample size, appearance or temperature may impact results.

The objective of sensory testing is to obtain a reliable score for the meat being tested. Good design will therefore work to reduce all the potential variables, or at least to balance them, so that a difference in score will reflect only two potential issues: a difference in the meat quality or a difference between individual consumers. If sufficient consumers are used per sample the second effect can be largely overcome so that a reliable score for the meat can be obtained.

The sensory Protocols developed by MSA and utilised in this study directly address the issues mentioned above. As indicated in the preceding section consumer screening insured that all who tested the product regularly ate Lamb and preferred it cooked medium. The screening process also addressed demographic effects.

Other issues were addressed within the procedures used for each session.

Each consumer was served a presumed mid range linking sample first, followed by six further samples. This aimed to start all consumer scores at a common, roughly central point. This procedure removed the risk of an initial good or bad sample being marked more centrally and then unrealistically displacing subsequent scores.

Backstraps from surplus heavier carcasses were prepared for link grills with as many people as possible served from each carcass to provide sensory linkage. Topside was used as the roast link. The utilisation of one cut over a large number of consumers provided an ability to compare their individual scores. This can assist identify habitually high or low scorers and provide a basis for statistical score adjustment should that be necessary.

The limitation to seven samples per consumer followed MSA testing which established that score accuracy was maintained to this number without fatigue effects becoming evident. The Protocols also demand a range of product so that of the six products served to each consumer one must be presumed high quality and one low.

This was achieved by varying cuts, hanging method and sheep type to construct the six 'products'. For the grilling tests the six products were created by utilising

Backstraps and Rumps from Achilles (AT) and Tenderstretched (TS) carcasses within three carcass weight ranges. Carcass weight ranges were used in lieu of division into Lambs, Hoggets and Ewes due to inconsistency in eartag data which was the link to the class of sheep.

The design may be seen in the product 'pick' presented on the Page 28, which details the cuts, hanging method and carcass weight parameters used. The Rumps and Backstraps used in products one and two were from common carcasses as were those in four and six. This provided excellent 'within animal' linkage. Products three and six were Backstraps from further carcasses, AT and TS hung, to increase the number of individual carcasses tested. Analysis of the Backstrap to Rump relationship from the product one/two and four/five pairing enabled confident calculation of the cut relativity's.

The roast sessions were similarly arranged with Topside and Silverside, from the same carcasses, substituted for Backstrap and Rump.

Eighteen cuts were allocated to each product, with both the grill and roast picks further grouped as:

- 6 from the lightest carcasses
- 6 from medium weight carcasses
- 6 from the heaviest carcasses.

The sensory software program then allocated each product according to a Latin square design so that products were served in three Latin squares over the pick. Pictorially this is a format of:

1	2	3	4	5	6
2	4	1	6	3	5
3	1	5	2	6	4
4	6	2	5	1	3
5	3	6	1	4	2
6	5	4	3	2	1

The use of 18 cuts per product ensured that each product was served an equal number of times in each presentational order position, an equal number of times before each other product and an equal number after each other product. This balanced out any possible effect arising from order, contrast to preceding samples or fatigue effects.

To guard against the chance of any group of consumers on any night generating an effect the software further allocated the samples from each individual cut to five separate presentational positions and five separate groups of consumers.

For grills, where the five samples (served to 10 consumers) were individually cooked the groups were five distinct groups of 20 people across a minimum of two nights. A total of nine groups of 20 people were utilised for the grill testing, three separate groups being used on each of three nights at three locations as detailed.

DESIGN FOR GRILL SESSIONS

	AT Product 1			AT Product 2			AT Product 3			TS Product 4			TS Product 5			TS Product 6		
	CarcID	Cut	SEQ	CarcID	Cut	SEQ	CarcID	Cut	SEQ	CarcID	Cut	SEQ	CarcID	Cut	SEQ	CarcID	Cut	SEQ
	109	BKS045	17197	21	RMP031	16904	96	BKS045	16590	118	BKS045	17720	118	RMP031	17737	48	BKS045	17441
	117	BKS045	17660	109	RMP031	17209	15	BKS045	16761	74	BKS045	17961	74	RMP031	17964	82	BKS045	17021
LIGHT	113	BKS045	17429	117	RMP031	17677	65	BKS045	17781	101	BKS045	16780	101	RMP031	16797	54	BKS045	17561
	21	BKS045	16901	113	RMP031	17439	43	BKS045	17341	64	BKS045	17761	64	RMP031	17764	36	BKS045	17201
	45	BKS045	17381	45	RMP031	17384	77	BKS045	16801	66	BKS045	17801	66	RMP031	17804	8	BKS045	16641
	55	BKS045	17681	55	RMP031	17684	9	BKS045	16661	114	BKS045	17480	114	RMP031	17497	20	BKS045	16881
	47	BKS045	17421	47	RMP031	17424	93	BKS045	17581	112	BKS045	17370	112	RMP031	17380	40	BKS045	17281
	91	BKS045	17481	91	RMP031	17484	83	BKS045	17041	26	BKS045	17001	26	RMP031	17004	38	BKS045	17241
MEDIUM	57	BKS045	17621	57	RMP031	17624	59	BKS045	17661	70	BKS045	17881	70	RMP031	17884	80	BKS045	16941
	29	BKS045	17061	29	RMP031	17064	92	BKS045	17541	105	BKS045	17020	105	RMP031	17037	78	BKS045	16821
	7	BKS045	16621	7	RMP031	16624	13	BKS045	16741	108	BKS045	17140	108	RMP031	17157	90	BKS045	17461
	102	BKS045	16840	102	RMP031	16857	19	BKS045	16861	10	BKS045	16681	10	RMP031	16684	42	BKS045	17321
	69	BKS045	17861	69	RMP031	17864	116	BKS045	17600	51	BKS045	17501	51	RMP031	17504	76	BKS045	17941
	87	BKS045	17141	87	RMP031	17144	81	BKS045	16961	56	BKS045	17601	56	RMP031	17604	97	BKS045	16626
HEAVY	5	BKS045	16581	5	RMP031	16584	39	BKS045	17261	99	BKS045	16720	99	RMP031	16737	110	BKS045	17250
	61	BKS045	17701	61	RMP031	17704	46	BKS045	17401	44	BKS045	17361	44	RMP031	17364	16	BKS045	16781
	85	BKS045	17101	85	RMP031	17104	119	BKS045	17780	86	BKS045	17121	86	RMP031	17124	18	BKS045	16841
	37	BKS045	17221	37	RMP031	17224	25	BKS045	16981	103	BKS045	16899	103	RMP031	16910	4	BKS045	16561

Roasting requires that the entire roast for 10 consumers be prepared at the one time which prohibits the use of the 5 x 20 grill design. A similar effect was created by serving three groups of 60 consumers, with one group per night. Each group of 60 was treated as five groups of 12 within the design process. The five samples (divided to serve 10 consumers) were each allocated to a different group of 12 and a different presentational order within the night.

The MSA software utilised automated many aspects of the complex design process saving both time and eliminating many sources of potential human error. In addition to the Latin square and session allocation detailed above the program also produced a file which was forwarded by email to Sensory Solutions.

This file was used to produce sheets of stick on labels used for the consumer questionnaires and plates used to present each sample. The labels carried the product code for each sample together with the consumer number and order to enable double-checking and control of the serving process.

The sensory design used provided a full range of sensory scores from both grilling and roasting to enable the elements involved in consumer judged eating quality to be established. This provided a base from which a consumer scoring system for subsequent product testing of Sheepmeat could be created. This is required to define what 'drives' the sensory differences as well as to establish linkage between cooking methods and enable accurate comparison of product tested over time. The critical requirement is to have a scoring system which accurately reflects consumer perceptions. Once established this allows definition of cause and effect throughout the production chain in addition to a consumer grading base.

Cooking Procedures

The cooking Protocols were adapted from the MSA beef experience.

Roasting procedures were virtually identical with roasts cooked in a commercial gas oven at 160°C until the core sample temperature reached 65°C, indicated by thermocouples located centrally within each sample. Upon reaching temperature the roasts were removed from the oven, 'rested' for a minimum of five minutes, trimmed further to 65mm x 65mm x 110mm and then placed on a 'toast-rack' like device within bain-maries which maintained a constant temperature of 50°C. This procedure enabled roast temperatures to be held within 1°C for 40 minutes ensuring that a single roast could be served in the required five positions over a standard 35 minute consumer test session.

The 'toast-rack' had a spike to locate the roast and a series of five slots at 10mm centres to provide a precise 10mm slice when a fine knife was passed down the slot.

Four people were used to carve, each with a separate bain-marie containing the required samples. Cutting and serving was controlled by a timer with each 10mm slice divided between two consumers in accordance with the pre-set order.

A SILEX double sided clam shell grill was used to cook the grilled product with plate heat and weight settings adapted for a 15mm thick Lamb sample. Ten samples (divided to serve 20 consumers) were cooked per 'round', with seven 'rounds' per session (group of consumers). Consumers who were paired to receive alternate halves of each sample were never seated adjacent to each other.

Software generated sheets controlled the sample allocation to the round (presentational order) and the individual consumers to meet the design requirements described above for both grilling and roasting.

In the grilling tests sacrifice product was cooked first to stabilise the SILEX plate temperatures with the timing of subsequent sample placement on and off the grill, closing of the top plate and duration of cooking controlled to the second by a timer. This provided repeatable uniform cooking and degree of doneness.

The preparation and cooking procedures are more fully documented in the attached Protocol.

Data Entry and Processing

All consumer questionnaire details were double entered by Sensory Solutions staff. The marks for each sensory scale were measured and recorded as scores out of 100 (equal to the mm from the left due to the line scales being 100mm) along with the market category box. An electronic check was conducted to ensure that the double entered results were in agreement, with any discrepancies checked and corrected.

The completed file was then emailed to Marrinya. A further electronic check was then run to match the individual products and presentational order recorded against the original design. Again this follows established MSA practice. Further comprehensive procedures were then used to group the ten individual consumer scores together for each cut tested.

A copy of the sensory results was then forwarded to Dr Ray Watson of Melbourne University and Dr John Thompson of UNE. Their initial analysis brief was to use the scores to establish parameters for consumer perception of Sheepmeat eating quality. .

Issues Arising from Consumer Sensory Testing

- As might be expected from such extensively Trialled Protocols the sensory testing element of the Trial ran smoothly to plan producing a full set of valid data.

  It is strongly recommended that the rigid and detailed Protocols utilised be continued for any future Sheepmeat testing.

- A sensible arrangement within MLA would be for much of the MSA consumer testing structure of services, software and equipment to be further utilised for Sheepmeat testing. It is recommended that a detailed agreement be pursued within MLA between the Sheepmeat and Beef programs.

4.6 Objective Testing

One Trial objective was to obtain data that would enable the strength of any relationship between consumer scores and objective measurement to be evaluated. As the muscle size from Lambs is considerably smaller than the corresponding muscles in beef, objective testing could offer a practical means of evaluating muscles which are of insufficient size to provide multiple consumer samples.

Objective testing may also cost less than consumer testing which would achieve research savings. A further possibility is to use objective testing as a 'screening' procedure to identify major trends or effects and then to refine the eating quality estimates by subsequent consumer testing.

In all cases the degree of usefulness is dependent on the strength of any relationship between consumer sensory and objective measurement data.

Unfortunately the amount of comparison possible from this Trial was restricted to the Backstrap due to the quantity of sample required. The lighter than expected carcass weight reduced product available, with the problem further exacerbated by preparing from the frozen primal.

Primals from both carcass sides had to be thawed to provide sufficient material for ten consumer samples. Because they had been previously frozen, samples could not be refrozen, even when there was an adequate sized block 'left over ' for objective testing.

In future work a higher percentage of objective samples could be obtained by preparing from the fresh state or by reduction in the number of consumer samples per carcass.

The matched Backstrap samples to those tested by consumers were forwarded frozen to the University of New England for objective testing. All cuts which have not been consumer tested remain in frozen storage and so are potentially available for further objective or consumer evaluation. The procedures used in the objective test are as described below.

Thawing and Ageing

To be comparable with the preparation of the sensory samples, the objective samples were thawed in a 1°C room and aged for an additional 7 days prior to testing. This was the mean of the 5, 7 and 8 days used for the sensory samples.

Sample Size and Location

65g blocks were prepared from both the *Mm. longissimus and semimembranosus* following thawing. The block was cut so that the fibre orientation was parallel to the long axis. A nick was made in the proximal face of the block to assist in orientation when cutting samples.

Meat Colour Measurement

A colour measurement was taken on the bloomed dorsal surface of each sample during preparation for cooking using the Minolta Chroma Meter (light source=C65, colour space=L*a*b*, multi-measure=yes).

pH Readings

One temperature and four pH readings across the bloomed dorsal surface were taken on each sample. Samples were returned to the chiller after measurement. On completion the electrode was rinsed and checked against both buffers.

Cooking

The samples were weighed and placed into thick plastic bags, folded, clipped, and hung on a water bath rack. They were arranged to avoid contact with each other to avoid uneven cooking. This required hanging adjacent samples at different heights. They were then placed into a pre-heated 70°C water bath for 30 minutes. The total weight of meat in a batch was kept constant with no more than 2 kg of meat cooked in one session.

To standardise the cooling procedure the cooked samples, whilst still on the rack, were cooled in a bath of cold, running tap water for 30 minutes. The samples were then removed from their cooking bags, paper-towel dried, weighed ('post-cook' weight recorded to one decimal place), returned to their cook bags, folded and stored overnight in a 1°C chiller.

Preparing Cook Samples for Lloyd Measurements

The cooked samples were taken from the 1°C chiller, removed from the bags and a slice was taken from the lateral side to give a flat, vertical surface.

Warner-Bratzler

A total of 6 samples were cut parallel to the fibre direction for objective testing. These were placed flat, marked and cut parallel to the fibre direction.

Warner Bratzler shear samples

The Warner Bratzler shear blade and block were attached to a Lloyd Testing Apparatus. Samples were inserted through the blade and clamped prior to shearing with the Warner Bratzler blade. A total of six shear readings were taken and a mean shear value for each sample calculated.

Measurement of Sarcomere Length

Sarcomere length was measured using the laser diffraction method described by Bouton et al (1972). A minimum of 5 slices per sample were measured to ensure a variation of no more than 0.2 μm between measurements.

The objective test results have been recorded in the Master Database allowing connection to all animal, processing and sensory data.

Issues Arising from Objective Testing

- The primary issue relating to objective testing was the limitation of available sample due to the conflict between that available and that required for consumer and objective testing. As discussed this was exacerbated by preparation from the frozen state.

  In future work it is recommended that all sample preparation be undertaken before freezing. This will require consideration of ageing periods.

- If short ageing is desired then the objective samples may need to be taken prior to consumer sample preparation. This would require acquisition in or close to the boning room with the objective samples ticketed, packed and frozen at the abattoir. This would create operational difficulties at many locations and would certainly require appropriately skilled and experienced staff in attendance.

Airfreight or other very rapid transport from the abattoir to the central specialised preparation room is an alternative but also likely to impose further cost and logistical complexity.

- An accompanying problem arising from early fabrication of objective test samples is to ensure that sufficient product remains to effectively cut the required consumer samples. When carcasses are of sufficient weight to obtain all consumer product from the one carcass side the problem is reduced, as freezing the cut from the alternate side for objective testing requires a lesser degree of expertise on site. Some variation in freezing pattern for objective testing may be encountered but should not be significant in most instances.

- A reduction in the quantity of consumer sample required per cut would also leave more available for objective testing. A further possibility might be to alternate the allocation of cuts to objective or consumer samples within reasonably homogenous carcass groups. Under this approach an objective block could be fabricated from a given cut along with the number of consumer samples was possible. These could then be accumulated from multiple carcasses into test sets.

  Further carcasses from the same group could be used to source full consumer samples with the objective sample omitted. Testing of the consumer samples from single and accumulated sets would provide reasonable, although imperfect, statistical linkage to enable any relationship to the objective results to be established.

  This approach would however require extreme care in planning, application of ticketing and data recording for analysis. It should not be attempted by other than highly experienced personnel as the relationship back to the computerised picking, product allocation and sensory result files is complex and results could be inadvertently compromised unless all the implications were fully comprehended and provided for.

4.7 Database Development and Structure

All available data relating to the sheep, transport, slaughter, chiller and objective measurements was recorded with identification by unique ticket numbers designated SEQRef (Sheepmeat Eating Quality) numbers.

All cuts were recorded, not just those consumer or objective tested, so that the database includes a large number of cuts which are in storage.

This data has been stored electronically in a number of databases to facilitate storage, retrieval, later additions and analysis.

The databases are as follows:

Master01

This is the principal database which records all data available for any cut collected aside from sensory results. Exclusion of sensory results provides for collation of all information relating to sheep, and derived samples, collected for testing prior to their allocation to a sensory test.

A further description of each column and its' function is attached as Attachment 3 in the Appendix. The column descriptions and groupings used reflect those believed most appropriate following consultation with some sheep industry researchers, coupled with experience from MSA beef research and this Trial. They should not be regarded as final however and are likely to benefit from future revision.

This database is grouped in sections to facilitate data entry and reference to specific data types. Sections are:

Identification

This section groups identifying data such as group, kill date, eartag and carcass numbers, cuts and muscles. Columns which provide an easy basis to group cuts from one carcass (KEY), carcass side (2ndBStrap) or to link a sensory result to multiple samples (Master SEQ Score) are also included. In addition this section records the status of a cut to identify if it has been tested and, if so, in which 'pick' and by what cooking method, or whether it is currently available for testing.

Slaughter Floor Data

Records slaughter floor measurements and treatments including electrical stimulation and carcass suspension method.

VIA Data

Records the averaged left and right carcass side VIA readings for each carcass.

pH and Temperature Decline Data

This details the pH and temperature readings taken by time. These columns are followed by calculated values which describe rates of decline to facilitate statistical analysis.

Animal Data

Records breed, age, growth and pre-slaughter handling information.

Objective Measurement Data

Records all objective measurements taken.

The SEQRef column is repeated several times at the commencement of various sections to assist in locating a particular sample within that section.

The database groups input data from a wide number of sources including breeder, abattoir and laboratory which requires careful management – firstly, to acquire all data and secondly, to ensure its' integrity and accurate linkage within the main database.

The database is arranged by carcass within group with all samples derived from a carcass grouped sequentially. The database row order is therefore group at the macro level, further divided into carcass, then to cut and, potentially, to samples within individual cuts.

Each row represents a unique SEQRef identified sample for testing. A large amount of information such as kill date, carcass number and weight, animal data etc is common for each SEQRef within a carcass.

For the database presented these columns have been copied down manually but the procedure would be best automated once a final format is agreed. This has been done in the beef MSA databases which have been largely used as a concept base in establishing the sheep files.

SHEEPGRILL01

This data file contains all sensory results from the grill testing. A description of each column is included in the Appendix (Attachment 4). Coded entries of demographic information from the consumer questionnaires is recorded together with the sensory scores awarded to each sample tasted by each consumer on a sheet titled "Sensory Original".

The ten sensory scores for each cut are grouped on a second sheet, "Cut Scores and Clipping" which also contains the clipped score calculations.

The final clipped score for each SEQRef is then presented on a third sheet in a form to facilitate linkage to the Master01 database information. This sheet is labelled "Cut Result Summary".

A final sheet entitled "Product Summary" provides a summary of product groupings tested in the 'pick' with CSEQ results for each sample and an average for the group.

SHEEPROAST 1 TO 3

This datafile is virtually identical to SHEEPGRILL01 in format and contains all sensory data from the roasted product tested. Attachment 4 in the Appendix also describes columns used in this file.

The two sensory files used were those provided for analysis of consumer-scoring patterns and to derive the basis for the CSEQ score. The CSEQ was calculated and added to the raw score data prior to calculation of the final sample (cut) scores.

COMBI01

This database combines the sensory data from SHEEPGRILL01 and SHEEPROAST1to3 with all other available matching data for these samples from Master01.

It includes all pertinent data for all samples for which consumer results have been obtained.

Cuts which have not been tested are not included. A single SEQRef number in the sensory databases may actually reflect a consumer result for two ticketed cuts on the Master01 database where cuts from both carcass sides have been utilised to prepare the required ten consumer samples. Associated cuts can be identified by a common Master SEQ Score in Master01.

Combi01 has been restricted to the single 'master cut" which has all production and sensory data presented on a single row. An alternative is to duplicate this data by also transferring the subsidiary matched cuts to Combi01.

Some Master01 columns relating to availability are not taken across to Combi01 as they are redundant, but all columns used in Combi01 are present in either Master01 or the two sensory files. These column headings are defined in Attachment 5 in the Appendix.

Combi01 is the relevant database for analysis of Trial results relating to cuts, animals or groups.

Issues Arising from Database Establishment

- Agreement needs to be reached on a final database layout and content. The columns in the Trial Databases reflect data available and suggestions from various sources. Some columns may be eliminated, more may need to be added and the order may be better changed. These decisions should be made by whichever group is to control product collection and analysis to ensure their needs are met. The issues and possibilities regarding some existing columns are discussed in Attachments 3, 4 and 5 in the Appendix, which detail the Database's column headings.

- A decision is required regarding transfer of subsidiary cuts to the Combi01 database. These are cuts identified by their common Master SEQ which have been used to make up a single set of consumer samples. At present only the single primary SEQRef cut has been transferred.

- Whatever the format, accuracy is imperative and will not occur without rigorous procedures and a total commitment to detail from all concerned. Collection, abattoir, boning room and sample fabrication practises must be defined.

- Once defined appropriate standardised data collection file formats must be agreed and rigorously applied. Smaller details such as the order of columns, standard headings and agreed time and date formats will streamline input and reduce the risk of mistakes.

  As the database is constructed by amalgamating inputs from multiple areas each will require detailed development and linkage.

- As the SEQRef is the constant unique reference point it must be linked to the data by absolutely failsafe means at the earliest possible point. Whenever possible unique ticketing generated from a specific Trial ticketing database should be used in preference to commercial alternatives such as kill order or carcass number which, while mostly right, can destroy integrity on the occasions they are wrong.

- Software should be developed to automate as much of the data management process as is feasible once agreement is reached on the file layout and specification. Specific areas where this may be most useful are:

- ⇒ Duplication of repeated columns
- ⇒ Fill down of data common to multiple samples
- ⇒ Calculation of appropriate columns
- ⇒ Filling of blank cells with NA or the agreed value
- ⇒ Error checking procedures to test values for range and format
- ⇒ Linkage to the Master01 and sensory databases to create Combi01

- ✫ Compatibility of file formats should be established with those likely to be involved in analysis. Some statistical programs are particularly inflexible in regard to spaces, dots, blanks etc. Definition in the establishment period can help avoid later compatibility problems.

4.8 Data Analysis

Results of the data analysis are presented in the following section. This analysis was conducted at a variety of levels and by two principal researchers.

Dr Ray Watson of Melbourne University was principally responsible for analysis of the consumer scoring data with Dr John Thompson of UNE independently running some sensory analysis.

Dr Thompson assumed responsibility for analysis of animal, processing and objective data and the relationship to sensory scores. It is planned to have Dr Watson also conduct some additional analysis of the animal and objective data. The use of independent analysis aimed to ensure that the broadest possible view was generated from the data collected to date along with definition of desired approaches for any future trials.

The data was assembled and merged by Judy Philpott who created and checked the various databases.

Collation of sensory data and application of the SEQ formula was done by Mary Porter who performs the same function for all MSA Beef consumer data.

Two matters which are of significance and more directly related to the nature of the data than to the findings presented in the later Results and Findings section are detailed below.

Issues Arising from Data Analysis

- There may be potential to utilise less than 10 consumers per sample for Lamb and Sheepmeat consumer testing. This would have a number of benefits including a reduction in cost and less difficulty associated with preparing the required number of samples from muscles of limited size.
- A change to either 8 or 6 consumers per sample should be further evaluated in any follow up Trials.
- The nature of the data is such that it would appear possible to develop an Eating Quality Prediction Model for Lamb and Sheepmeat.
- Considerably more data incorporating an appropriate range of sheep, processing treatments and cooking techniques would be required to develop an acceptable Prediction Model. Addition of further trial data to the databases established would provide a suitable base.
- A majority of issues which arose from the data analysis are presented in the following Results and Findings section.

5.0 Results and Findings

5.1 Consumer Eating Quality Perception

The major aim of this Trial was to define the basis of consumer perception of Lamb and Sheepmeat quality. Current and past practice has relied on trade knowledge of 'what is good' based on experience.

In general there is bound to be a large element of truth in the generally held beliefs. Lamb is likely to be 'better' than older sheep, backstrap is likely to be 'better' than brisket, but why, and how, by how much and what factors create the differences?

To make significant improvement in meeting consumer needs there are two requirements. The first is to define the target, which is why an understanding of consumer sensory perception is critical. The second is to meet the target more precisely by defining which aspects of the total production process affect eating quality and then managing each factor more effectively.

This Trial was of sufficient size to investigate the first issue, the components of consumer sensory perception, although considerably more experimental data would be required to define the detailed impact of production inputs.

There are again two aspects to the consumer perception question. The first is what 'drives' consumer sensory perception and preference. How important is Tenderness relative to Flavour, or either to Juiciness? How might these different factors interact?

The follow on question of relevance, once the base component interactions are defined, relates to different quality levels or grades. How many can consumers reliably differentiate, where are the ideal boundaries between them and are these consistent across different consumers or groups?

This Trial was designed to address these two core sensory issues. The choice of product from old and young sheep aimed to create flavour differences. The use of Achilles tendon and Tenderstretch hanging in conjunction with four cuts aimed at creating a full product range. The use of two cooking methods provided a test across cooking methods.

Having 'designed in' a product range efforts were then made to 'design out' all other potential sources of variance. The detailed Protocols for cut preparation, cooking and serving consumers defined these issues and have been discussed earlier.

The evaluation of what 'drives' eating quality is best attempted without reference to any aspect of product knowledge. The aim was not to know whether this was 'good for topside' but rather the definition of 'good'. To this end the consumer score sheet data was supplied for analysis without any related information.

Primary analysis was conducted by Dr Ray Watson of Melbourne University with Dr John Thompson of UNE also independently conducting some level of analysis for the same raw data set. A copy of Dr Watson's report is included in the Appendix as Attachment 6.

The individual consumer line scale scores for each attribute for each sample were provided along with the category box selection from the score sheets. This data is provided electronically in SHEEPGRILL01 and SHEEPROAST 1 to 3.

The individual scores ranged from 0 to 100 for each scale as is shown in the Table below.

SUMMARY OF CONSUMER SCORES BY SCALE

Scale	No. of Scores	Mean	StDev	Min	Q1	Med	Q3	Max
Tender	2520	62.3	23.1	0	46	64	80	100
Juicy	2520	61.7	21.6	0	47	63	80	100
Flavour Strength	839	61.2	18.9	0	50	60	76	100
Flavour Liking	2520	60.7	22.6	0	45	61	80	100
Overall Liking	2519	61.1	23.0	0	46	61	80	100

The mean is the average value for the score whereas the median (Med in the Table heading) is the mid or central score. Q1 is the first quartile or lowest 25% boundary value whereas Q3 is the third quartile boundary representing the point separating the top 25%.

The number of flavour strength scores was much lower as the Trial aimed to test the potential value of using flavour strength either in addition or in lieu of flavour liking.

From a statistical viewpoint the Table values demonstrate a normal distribution where the scores if graphed would appear as 'bell shaped curves', with the highest number grouped around the mean value and numbers decreasing either side as the values differ more from the mean.

A second follow on statistical test was to evaluate the correlation between the scales. This indicates how much factors tend to follow a similar trend. An example might be overall liking improving as tenderness and flavour improve. The correlation's found are shown below.

Correlation between Sensory Scores and 'Star' Category

Scale	Flavour Strength	Juicy	Tender	Like Flavour	Overall
Juicy	0.503				
Tender	0.407	0.737			
Like Flavour	0.509	0.663	0.642		
Overall Liking	0.486	0.713	0.721	0.915	
'Star' Category	0.410	0.629	0.677	0.752	0.798

The 'star' category reflects the box ticked on the consumer questionnaire and it may be seen, as might be expected, that the overall liking scores are highly correlated with the quality box selected.

The other scales are also well correlated with the category and with each other, with the exception being flavour strength.

As flavour strength was recorded on a lesser number of score sheets a further check was conducted using only those sheets which had all five scales completed. This produced a very similar result, indicating that flavour strength was not as strongly related, or correlated, to the overall eating quality category.

The next analysis stage was to evaluate the scoring pattern for each scale by category, or grade. The results are summarised in the following table, with the headings similar to the first table. The tenderness scores are displayed for all samples within a category group or star reflecting the linkage between the mark a consumer placed on the tenderness scale and the box ticked.

Consumer Score Pattern by 'Star' and Sensory Scale

Scale	'Star'	No. Of Scores	Mean	StDev	Min	Q1	Med	Q3	Max
Tender	2	417	36.5	21.6	0	20	34	48	98
	3	1085	56.9	17.8	3	44	60	69	100
	4	676	74.1	14.5	8	66	77	83	100
	5	341	87.7	10.7	20	80	90	95	100
Juicy	2	417	39.0	20.8	0	24	40	51	99
	3	1085	57.3	16.9	8	46	60	70	100
	4	676	71.4	15.6	25	62	73	80	100
	5	341	84.1	11.9	24	80	85	93	100
Flavour Strength	2	149	50.8	21.9	0	36	50	65	100
	3	361	57.2	16.8	7	47	60	69	100
	4	229	68.5	14.8	27	60	70	80	100
	5	100	74.5	16.1	18	65	80	85	100
Flavour Liking	2	417	30.3	16.3	0	20	30	40	84
	3	1085	56.1	15.8	2	46	57	67	100
	4	676	73.7	12.8	23	65	75	80	100
	5	341	86.8	11.1	5	80	88	95	100
Overall Liking	2	417	28.2	14.7	0	19	29	40	68
	3	1085	56.1	14.6	3	47	57	65	95
	4	676	75.4	12.1	20	68	77	83	100
	5	340	88.7	10.0	5	84	90	96	100

Thus from the Table it can be seen that individual consumers marked the unsatisfactory or '2 star' box 417 times and the premium '5 star' box 341 times with the 3 star and 4 star boxes more frequently ticked on 1085 and 676 occasions respectively.

This reflects the general pattern of the data with more samples regarded 'good everyday' quality, but also provides sufficient poor and excellent samples to statistically derive sensible assumptions as to what contributes to consumer perception at each level.

The Table also presents a view of the general scoring pattern. For each scale the mean advances steadily as the category or grade increases. Thus, for tenderness, the mean or average score for the grades is 36.5, 56.9, 74.1 and 87.7 progressing from unsatisfactory (2 star) to premium (5 star).

This pattern is repeated for the other statistical measures; the minimum, quartile, median and maximum values.

The minimum and maximum values also illustrate the challenge of creating grade categories for all consumers. Consumers are inherently variable, as is well demonstrated by the score range.

For example while consumers have rated samples unsatisfactory with tenderness scores of 0, at least one has scored tenderness 98 and yet still marked the unsatisfactory box. Similarly in the premium category tenderness scores range from 20 to 100.

Within this range however lies the sensible bulk of scores reflected in the mean. The aim in establishing an industry standard or set of grades is to represent the bulk of the population. It will never be possible to be accurate for every individual. The aim is to establish something that 'makes sense' across the population.

Having established the pattern of scores demonstrated above, the next analysis step was to determine how to best combine the variables to achieve a best fit single eating quality score in relation to the category box selected.

This was addressed by detailed statistical modelling with five, four and three scales included. As a total composite eating quality score is contributed to in some part by each component, the more scales included the less weighting is attached to each. In constructing the statistical models scales showing no significance or of minimal importance are removed with the result that those scales remaining 'weight up' as the deleted scales' component is distributed.

This adds importance to the major scales but also provides further indication of their relative importance judged by the proportion of the discarded score applied to each by the statistical package.

In this instance the flavour strength scale was deleted due to its' relative poor performance. The analysis demonstrated that it was of lesser value in explaining or predicting consumer judged eating quality and that it did not add useful value beyond information from flavour liking. Accordingly Dr Watson's recommendation was to drop this scale from future testing and not include it in calculations of the composite eating quality score.

The Overall scale was then deleted to gain a better understanding of the relative impact of Tenderness, Juiciness and Flavour Liking, each of which contributes to the Overall Liking value.

This progressive analysis produced prediction formulae for each category or 'star' which provided an indication of the ideal relative scale values. Examples from Dr Watson's report are:

With all variables included:`

Star = 1.26 + 8.4 (Tender/100)- 0.4 (Juicy/100) – 0.5 (Flavour Str/100) + 7.0 (Like Flavour/100) + 20.0 (Overall/100)

It can be seen that overall was most important followed by Tenderness and Flavour Liking but that Juiciness and Flavour Strength were small.

With Flavour Strength removed:

Star = 1.23 + 8.1(Tender/100) + 1.0 (Juicy/100) + 6.3 (Like Flavour/100) + 19.3 (Overall/100)

Juiciness assumed some small importance and the other variables retained a similar relativity.

When Overall was removed to test the remaining three scales the result was as follows:

Star = 1.2 + 11.6 (Tender/100) + 2.9 (Juicy/100) + 20.8 (Like Flavour/100)

As can be seen a majority of the score previously allocated to 'Overall' transferred to Flavour Liking indicating the importance of flavour in eating quality perceptions of Lamb and Sheepmeat.

In practise it was desired to retain the Overall scale in the eating quality calculation due to its excellent correlation. It also provided value in being able to 'float' somewhat in meaning across the quality range.

This is demonstrated by further analysis which yielded the following weightings and cut off scores for each 'grade'.

Optimum Scale Weighting and Cut-Off Boundary by Grade

Grade Boundary	Score Weighting				Cut Off Value
	Overall	Flavour	Tender	Juicy	
Fail/3 Star	0.68	0.16	0.16	0.00	44
3 to 4 Star	0.60	0.15	0.26	0.00	65
4 to 5 Star	0.34	0.27	0.23	0.12	80

The cut-off values shown are technically the most appropriate grade boundaries.

As is shown the optimum weightings for each of the three sensory attributes varies for each grade. When applying a grade in practise it is not possible to 'change the rules' for each sample, grade, week, or set of data so that a single more robust formula needs to be developed.

If only Tender, Juicy and Flavour were used any weighting would tend to be inappropriate at one end of the scale. An example is demonstrated by the change in flavour weighting as the grade increases. The inclusion of the Overall scale overcomes this problem by absorbing changes in emphasis between the other traits across the range.

Use of the four variables provides a single formula that can produce an accurate result for samples of all quality grades.

Further analysis from Dr Thompson supports the above. Dr Thompson's study was conducted within carcass weight, cut and cooking groups reflecting the files provided which included this information. The relative weightings arising from his discriminate analysis are shown in the Table below.

Grill Weightings

Scale	Lambs & Hoggets				Ewes				Average
	Backstrap		Rump		Backstrap		Rump		
	AT	TS	AT	TS	AT	TS	AT	TS	
Tender	26	19	14	35	24	17	28	1	21
Juicy	12	13	11	7	3	12	4	16	10
Flavour	24	10	13	28	19	18	11	24	18
Overall	38	58	62	30	54	53	56	59	51

Roast Weightings

Scale	Lambs & Hoggets				Ewes				Average
	Topside		Silverside		Topside		Silverside		
	AT	TS	AT	TS	AT	TS	AT	TS	
Tender	15	16	35	26	27	9	8	18	19
Juicy	9	3	14	4	3	17	6	11	8
Flavour	17	17	1	54	7	7	4	14	15
Overall	59	65	49	16	63	67	83	58	57

Division of the data into these smaller subclasses demonstrates a generally consistent pattern, with some variation as might be expected, given the small number per subset. The allocation to Lamb and Ewe was also based on carcass weight which, while generally correct, may not be accurate in all cases. Carcass weight was used for sensory group allocation to overcome problems encountered with eartag inconsistency.

Dr Watson's work was deliberately conducted entirely from consumer scores without reference to any other production data. This reflected the objective of developing a single score basis which accurately reflected consumer sensory perceptions independent of any production factors or influences.

Dr Watson's recommendation after consideration of all the analysis conducted and the raw data was to adopt a Sheepmeat eating quality score, designated SEQ in this report and the attached data.

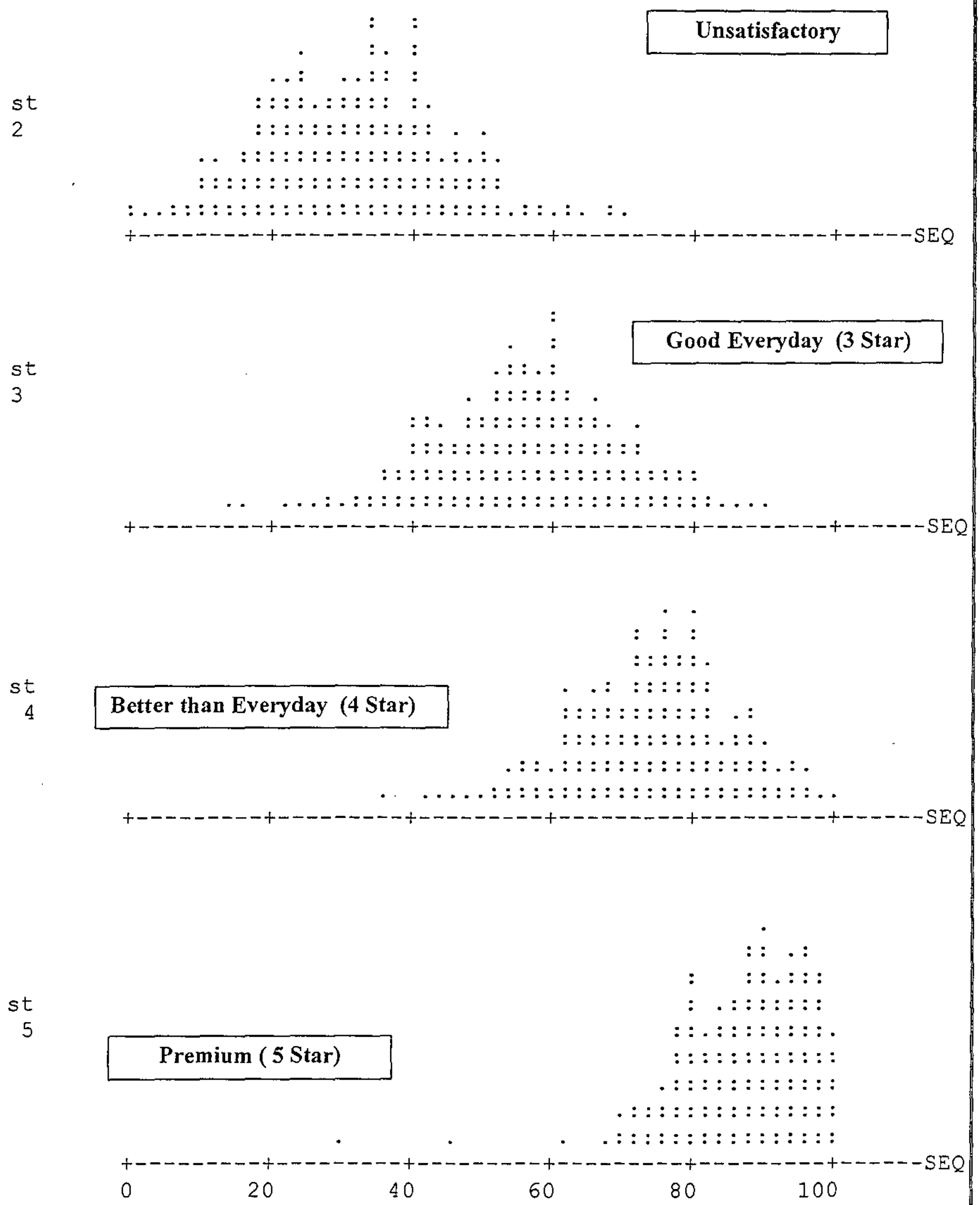
The recommended score calculation basis was:

0.4 x Overall Liking
+ 0.3 x Flavour Liking
+ 0.2 x Tenderness
+ 0.1 x Juiciness

= SEQ Score

The Juiciness component could be omitted on pure statistical grounds but it is felt that it should be retained at a minor level. It is already significant at the 4/5star boundary and later testing might generate product which varied more in Juiciness, thereby warranting greater consideration.

When the SEQ formula recommended above was applied to all the consumer data and the results graphed by category the pattern was as shown on the following page.


Unsatisfactory
st 2
SEQ
Good Everyday (3 Star)
st 3
SEQ
st 4
Better than Everyday (4 Star)
SEQ
st 5
Premium (5 Star)
SEQ
0
20
40
60
80
100

This pattern shows a relatively good fit across the entire range of individual consumer scores. As discussed in earlier sections a clipping procedure is applied to scores in practise to remove the highest and lowest scorers. This prevents a widely abherrrent score, such as a 100 rating by one consumer versus consistent values of 20 to 30 from the other nine who tested a sample, distorting the score for that cut.

Where ten consumers are used it is recommended that the top two and bottom two scores be clipped prior to producing a final CSEQ (clipped Sheep Eating Quality) score for a sample by averaging the central six values.

A further observation noted in Dr Watson's report is that less than 10 consumers may be adequate due to the relative consistency of the data. This issue has been discussed earlier, along with the recommendation that it be pursued further.

A graph of clipped scores would appear even 'tighter' than that shown due to removal of the extreme values. Even at the unclipped level however the distinct pattern associated with each 'grade' is evident.

Also evident is the region in which it is best to divide the various grades. At any point some consumers will have ranked a sample higher or lower, as shown by the overlap seen in the graph. The majority however will agree with the grade allocated.

When the optimum weighting of Tender, Juicy, Flavour and Overall Liking shown in the previous table is applied to each sample in the unclipped data the agreement between the calculated 'grade' and the box ticked by consumers was 64.5%. When the practical approach of calculating by the SEQ formula was used the fit was 63.2%, an excellent result.

For a sample falling 'in the middle' of a grade virtually all consumers will agree with the grade provided. For a sample 'near the line' a greater number will rate it in the adjoining grade, but will still agree it is close to the boundary, meaning they are likely to accept the grade in practice.

More 'safety' in grade allocation can be built in by moving the minimum score up from the point of best fit. The downside however is that a greater percentage of acceptable product will be downgraded.

The recommended CSEQ formula and grade cut offs (CSEQ scores of 44, 65 and 80) are regarded as sound and highly unlikely to require change in the light of additional data. It would be good practice however to regularly re-calculate the values as a routine procedure over time. This provides a means of tracking any drift in consumer sensory perception over a period and ensures that a Lamb and Sheepmeat quality grading system is continually referenced against consumer set standards.

The core value of a consumer grading system must be its direct reflection of consumer standards. These provide an optimum benchmark from which to evaluate the impact of the full range of production variables.

An understanding of these relationships in turn would provide a base from which to develop a Prediction Model able to assign a consumer based grade to cooked product derived from a full range of Lamb and Sheep carcasses.

5.2 Principal Determinants of Eating Quality

The number of sheep cuts tested in this Trial falls considerably short of that required for a definitive study of eating quality determinants. This limitation is further compounded by the absence of animal data for a majority of the sheep supplied.

The sensory results are comprehensive however for the cuts tested and the pH temperature data is complete, providing an opportunity to study any eating quality effects from the mix of carcass hanging and temperature/pH relationships.

It is possible therefore to seek general trends from the data on some key points. Trends which are evident are likely to be strong influences and also provide a measure of sensitivity for the consumer testing process. Only factors which consumers can differentiate are of importance in the commercial application of results.

Conversely if few differences were observed or results were erratic one might question either the veracity of the test procedures or the degree of agreement among consumers regarding eating quality. A lack of such agreement would render a consumer based grading system of little value.

The larger the differences and the more consistent the judgement the more effective a grading system can be and, by extension, the more helpful to consumers and the industry.

A summary of the raw results is presented in the following Tables. These Tables contain the clipped score averages and calculated CSEQ values for each carcass weight class by cut and cooking method before any form of statistical adjustment or correction. Due to the balanced nature of the experimental design these raw results provide a reasonable overview.

GRILLS

Backstrap

Hang	Weight Class	No.	Category	CLIPPED SCORES				
				C-Tender	C-Juicy	C-Flavour	C-Overall	CSEQ
AT	L	12	3.63	70	69	69	68	68
	M	12	3.59	67	66	69	68	67
	H	12	3.61	66	68	67	67	66
	All	36	3.61	67	67	68	68	67
TS	L	12	3.47	63	64	66	67	66
	M	12	3.73	69	71	70	71	70
	H	12	3.63	71	72	71	71	71
	All	36	3.61	68	69	69	69	69

Rump

Hang	Weight Class	No.	Category	CLIPPED SCORES				
				C-Tender	C-Juicy	C-Flavour	C-Overall	CSEQ
AT	L	6	3.13	58	59	58	60	59
	M	6	3.0	54	51	52	53	53
	H	6	3.08	53	58	55	54	55
	All	18	3.07	55	56	55	56	56
TS	L	6	3.15	56	54	58	58	58
	M	6	3.37	69	61	62	63	63
	H	6	3.3	62	63	61	59	61
	All	18	3.27	62	60	60	60	60

ROASTS

Silverside

Hang	Weight Class	No.	Category	CLIPPED SCORES				
				C-Tender	C-Juicy	C-Flavour	C-Overall	CSEQ
AT	L	6	3.06	51	49	51	51	51
	M	6	2.93	50	51	52	51	51
	H	6	3.0	53	53	54	51	53
	All	18	3.0	51	51	52	51	52
TS	L	6	3.3	60	58	55	56	57
	M	6	3.5	69	66	65	64	64
	H	6	3.4	67	65	65	66	65
	All	18	3.4	65	63	61	62	62

Topside

Hang	Weight Class	No	Category	CLIPPED SCORES				
				C-Tender	C-Juicy	C-Flavour	C-Overall	CSEQ
AT	L	12	3.2	57	55	55	55	55
	M	12	3.1	53	54	54	53	54
	H	12	3.3	64	60	57	58	59
	All	36	3.2	58	57	55	55	56
TS	L	12	3.6	67	64	64	66	66
	M	12	3.6	73	69	67	70	69
	H	12	3.5	70	65	67	67	67
	All	36	3.6	70	66	66	68	67

A number of issues are immediately evident. The cut scores are different, and sensibly so. Backstraps outperform Rump when grilled, Topsides roast a little better than Silversides. The beneficial effect of Tenderstretch hanging is also strongly evident in the Rumps, Topsides and Silversides.

The following Table further illustrates these factors, displaying the percentage of cuts tested attaining each grade within the cooking, cut and hanging treatments.

Grade % By Cooking Method, Cut & Hanging Treatment

	GRILL				ROAST			
	Backstrap		Rump		Silverside		Topside	
	AT	TS	AT	TS	AT	TS	AT	TS
Fail	-	-	5	-	22	5	8	3
3 Star	39	25	78	61	61	56	69	36
4 Star	53	72	17	39	17	39	20	56
5 Star	8	3	-	-	-	-	3	5
No. Samples	36	36	18	18	18	18	36	36

These trends all demonstrate that the consumer testing system is sensitive and consistent enough to identify inherent differences between cuts and process generated changes.

From this it can be confidently predicted that a workable Prediction Model is feasible given a sufficient volume of consumer test data.

Dr Thompson analysed the completed Combi01 file to examine potential animal and treatment relationships to eating quality as defined by the SEQ score.

In this he conducted some evaluation of sheep market class (ewe, hogget, lamb) within the overall data. Due to problems detailed earlier this reduced the number of samples to those able to be categorically identified via eartag to carcass linkage.

The following table from his report, Attachment 7 in the Appendix, details the means and variance by sheep class.

Means and Variance for Sheep Eating Quality (SEQ) Scores within Category and Hang treatments

Category	Hang	Muscle/cook	No	Mean	STDEV	Min	Max
EWE	AT	Backstrap/grill	14	69.8	8.55	51.1	81.3
		D Rump/grill	8	53.5	7.81	44.0	66.5
		Silverside/roast	8	49.7	6.19	37.8	58.0
		Topside/Roast	14	56.2	8.30	39.5	67.4
EWE	TS	Backstrap/grill	12	69.3	10.19	46.8	83.6
		D Rump/grill	6	53.5	9.83	44.5	69.7
		Silverside/roast	6	51.9	13.5	26.4	61.0
		Topside/Roast	12	62.6	8.71	43.2	74.2
HOGGET	TS	Backstrap/grill	5	71.0	4.80	64.0	76.5
		D Rump/grill	5	66.4	3.64	62.9	72.5
		Silverside/roast	5	71.1	6.81	61.9	77.3
		Topside/Roast	5	70.2	7.79	58.2	76.9
LAMB	AT	Backstrap/grill	15	63.5	7.13	52.3	76.2
		D Rump/grill	8	56.5	6.94	49.3	69.5
		Silverside/roast	8	53.7	15.26	30.8	74.0
		Topside/Roast	15	54.6	6.94	45.3	66.0
LAMB	TS	Backstrap/grill	16	68.5	3.34	63.5	73.3
		D Rump/grill	4	65.7	8.7	57.8	75.2
		Silverside/roast	4	64.2	6.59	58.7	73.1
		Topside/Roast	16	68.8	7.27	58.5	84.1

This is of course a very limited dataset and it should not be interpreted too literally. It is however useful in demonstrating that 'not all is as it is thought to be', or certainly not on all occasions.

In this instance Tenderstretch has shown a large benefit on the lambs but little if any on all cuts bar Topside in the ewes. The ewes have produced generally very high scores, comparing more than favourably with the lambs.

This does not indicate that 'ewes eat as well as lambs' but does explain the need to use a multitude of factors in combination to reliably estimate a CSEQ result. Buying 'lamb' will not ensure eating satisfaction if lairage management falls down, the carcass is cold shortened, pH is out of range and so on.

Analysis of the grilling results suggested that a session effect existed. This did not relate to consumer demographic factors. It may have reflected further impact of ageing variation through conditions from thawing to cooking beyond random variation. This underlines the merit of the sensory design which spreads an individual animal across multiple sessions.

Dr Thompson also used mixed modelling statistical procedures to examine the various major effects and potential interactions. The Table below from his report provides some information on principal factors via the relative size of the f ratios, an indication of comparative importance.

F ratios and df for the Effects of Category, Hang and Cook(cut) on Sensory Dimensions

Effects	N,D df	CSEQ	CTNDR	CJCY	CFLVR	COALL
Category	1,56	**5.77**	**5.29**	2.90	**5.06**	**5.12**
Hang	1,56	**15.37**	**12.51**	**10.83**	**13.21**	**14.68**
Cook(CUT)	3,108	**18.98**	**8.71**	**17.31**	**19.26**	**19.14**
HANG*COOK(CUT)	3,108	**3.79**	**3.87**	**2.82**	**3.47**	**3.41**
HANG*CAT*COOK(CUT)	10,108	**2.23**	0.86	1.73	**2.60**	**2.28**
Temperature @ 1 hour	1,108	**4.97**	3.93	2.75	2.28	**4.87**
(Temperature @ 1 hour)	1,108	**4.68**	3.71	2.53	2.12	**4.57**

Bolded F ratios are significant at P<0.05.

Again some care in interpretation is warranted due to the small dataset and nature of the test comparisons. The Cook (Cut) effect shown is most important but the relative effect of cook versus cut cannot be determined as each cut was only cooked by a single cooking method.

To develop a detailed understanding for any consumer score Prediction Model linkage would be required. This would require cooking the same cut by different cooking methods, thereby separating the effect and allowing valid comparisons to other cut and cooking method combinations.

The relative importance of the carcass hanging method continues to be demonstrated and is more directly interpretable as the cooking methods and cuts were distributed across both AT and TS.

Category of sheep and loin temperature at one hour post mortem are the next most significant factors. The variations in lairage management and interactions between carcass weight, fatness and chilling rates may well have influenced the category results which it is believed should be treated with caution.

The temperature relationship at one hour is of interest with an optimum CSEQ relationship at 32°C in this trial. More detailed follow-up work with a controlled range of temperature and variation in pH decline could be worthwhile and provide an improved base from which to improve eating quality and reduce variation.

Temperature and pH conditions could be expected to have a strong relationship to the degree of improvement with ageing.

This trial was not designed to provide definitive answers on the full range of animal and processing effects on eating quality. To pursue these to the point of building a useable 'MSA' style Prediction Model requires considerably more data, accumulated over time and encompassing a full range in all important variables.

The database developed in this trial is however a solid starting point and the lessons learnt should assist in later development.

5.3 The Use of Objective Measurement

A number of objective measurements were recorded in this trial to provide some indication of their ability to predict eating quality as measured by consumers.

Abattoir recordings were made with VIASCAN equipment in addition to manually recorded carcass weight, pH and temperature decline data. The VIA data encompassed various fat measures, eye muscle area and colour spectrums for meat and fat. These measurements were taken on all carcasses.

Further laboratory measures were obtained for 37 of the 72 Backstraps consumer tested. Laboratory tests were for chemical fat %, sarcamere length, cooking loss, Warner Bratzler peak force, meat colour (minolta lab) and pH.

Dr Thompson's analysis investigated each of these separately and in combination against each of the individual sensory traits and against the CSEQ score.

The correlation's were mostly not very strong for any single trait as shown in the table below from his report.

Simple Correlation coefficients between sensory dimensions and measurements made at slaughter, and in the laboratory

	CTNDR	CJCY	CFLVR	COALL	CSEQ
Chiller					
CARCWT	0.12	0.28	0.22	0.11	0.17
VIAEMA	0.21	0.18	0.28	0.16	0.21
VIACSITE	0.00	0.11	0.17	0.15	0.12
VIAGR	0.22	0.19	0.26	0.20	0.22
VIAR	0.20	-0.27	0.11	0.06	0.09
VIAG	0.21	-0.20	0.17	0.11	0.16
VIAB	0.16	-0.21	0.16	0.08	0.13
VIAMC	-0.32	0.14	-0.15	-0.12	-0.17
VIAFR	0.09	-0.10	-0.23	-0.19	-0.19
VIAFG	0.10	-0.07	-0.18	-0.15	-0.14
VIAFB	0.12	-0.07	-0.15	-0.11	-0.11
VIAFC	0.00	0.00	0.00	0.00	0.00
Laboratory					
SARC	0.11	0.21	0.10	-0.04	0.08
CHEMFAT	-0.16	0.01	0.12	-0.03	-0.02
OBJPH	0.15	0.02	0.05	0.11	0.10
OBJL	0.08	**-0.33**	-0.05	-0.22	-0.16
OBJA	-0.02	0.31	0.20	0.11	0.14
OBJB	-0.05	0.06	0.15	-0.03	0.02
CKLOSS	-0.17	-0.26	**-0.34**	-0.30	-0.28
OBJPF	-0.24	**-0.37**	**-0.39**	**-0.35**	**-0.37**

Correlations which were significant at P<0.05 are bolded.

Of all the measures Warner Bratzler peak force was the only one to achieve significance ($p<0.05$) in more than a single category and then at a low level. The 'l' minolta colour value and cooking loss achieved a single significance rating which is more likely of curiosity than value.

Combining the variables in a statistical model somewhat improved the result but not to a level which would provide any confidence in predicting eating quality on an individual sample. A trend might be interpreted across large numbers but the cost of this could well outweigh that of consumer testing.

The result of the combined model is shown in the following table.

Statistical Model R^2 and Residual Standard Deviation by Sensory Trait.

Traits	CSEQ	CTENDER	CJUICY	CFLAVOUR	COVERALL
R^2	36.4	41.1	51.1	41.3	32.8
RSD	4.86	6.34	6.0	5.21	5.32

Variables included were significant at $P<0.05$

The variables included in the model were Warner Bratzler peak force, carcass weight, VIA r,g and b values, VIA muscle colour, laboratory l value and chemical fat %. As can be seen the relationship of objective to sensory scores was in the order of 30 to 50%.

While the samples tested included a wide range of chemical fat and sarcamere lengths only fat contributed to the statistical model and then in a relatively minor manner.

Dr Thompson's report in the Appendix provides greater detail than the summary above. From this study the value of objective testing does not appear very high. It may however have been reduced by several of the operational issues discussed in early report sections.

In particular the ageing period may have reduced variance and any related ability to improve predictions although objective and sensory samples were aged similarly. Only Backstrap was tested due to cut size and the practise of preparing consumer samples from frozen primals as discussed earlier. This is however the most common muscle used in meat science studies.

Further studies at lower ageing periods and across more samples from a greater number of muscles may well improve the performance of objective testing. It must also be acknowledged however that a consumer score which is heavily weighted toward flavour may continue to prove difficult to predict by objective means.

APPENDIX

ATTACHMENT 1

Sensory Testing of Lamb & Sheepmeat Protocols
(Hard Copy + Electronic Copy)

ATTACHMENT 2

Consumer Questionnaire
(Hard Copy + Electronic Copy)

ATTACHMENT 3

Database: Master01 Column Descriptions
(Hard Copy + Electronic Copy)

ATTACHMENT 4

Sensory Database: Column Descriptions
(Hard Copy + Electronic Copy)

ATTACHMENT 5

Database: Combi01 Column Descriptions
(Hard Copy + Electronic Copy)

ATTACHMENT 6

Sensory Report from Dr Ray Watson
(Hard Copy + Electronic Copy)

ATTACHMENT 7

Analysis Report – Dr John Thompson
(Hard Copy + Electronic Copy)

ATTACHMENT 8

Animal Database: Master01.xls
(Electronic Copy)

ATTACHMENT 9

Sensory Results for Grilled Product: SheepGrill1.xls
(Electronic Copy)

ATTACHMENT 10

Sensory Results for Roasted Product: Sheep Roasts1to3.xls
(Electronic Copy)

ATTACHMENT 11

Combined Sensory and Animal Database: SheepCombi01.xls
(Electronic Copy)