Chapter 6: A QUALITY AUDIT OF OBJECTIVELY MEASURED PARAMETERS OF BEEF PASSING THROUGH SOME TYPICAL DOMESTIC WHOLESALE OPERATIONS

6.1 SUMMARY

Large variations in the meat quality traits of meat colour, pH, marbling percentage and texture/firmness exist between and within the various Aus-Meat cipher categories and processor establishment numbers.

Forty-one percent of all beef tenderloins assessed failed to meet a common food service industry specification. However this varied considerably between Aus-Meat cipher categories with only 17% of the Prime category failing with up to 57% of "A" category failing to meet the specification.

Forty-four percent of processors assessed achieved above 70% of their product in specification while 4 or 11% of processors attained 100% of product outside the specification.

Overall 22%, 9.5% and 10% of product failed to meet the specification on pH, meat colour and texture/firmness respectively.

Thirty-three and forty-three percent of product failed to meet the specification from grainfed and grassfed tenderloins respectively. The mean pH of tenderloins supplied to the food service industry was 5.64 with a minimum of 5.38 and a maximum of 6.61. The pH of "A" Aus-Meat cipher category product is significantly higher than the other cipher categories. There is a large variation in the mean pH, meat intensity (meat

colour) and marbling percentage of meat between processors with three processors' pH mean being above 5.8 pH. There is no difference between the mean pH of grainfed and grassfed product, however grainfed product is lighter in meat colour but in this study had lower marbling percentages. Older cattle (Aus-Meat cipher categories "A", Prime and "S") had higher marbling percentages than younger cattle (Aus-Meat cipher categories Yearling and Young). Only 4.2% of beef tenderloins assessed had a marbling percentage above 2.8% (equivalent to Aus-Meat Marbling Score 2 or above). Seasonal trends for meat quality traits were inconclusive except for marbling percentage which deteriorated over the time of the audit.

6.2 INTRODUCTION

The Australian Food Service Industry supplies customers with a very diverse range of red meat products. These products range from beef trimmings for hamburger enterprises to the highest quality cuts used in the hotel fine dining service.

This audit was carried out to assess the variation in objectively measured traits of products supplied to the airline catering, five-star hotels/restaurants, mid-level bistros/restaurants, professional catering firms, hotels, clubs and the institutional establishments situated on the east coast of Australia.

The objectives of the audit were:-

1. To investigate the relationship between Aus-Meat cipher category of carton product (definitions of Aus-meat cipher categories used are included in appendix 6.1) and the quality and consistency of product within the carton;

2. To relate the quality of supply to the quality and specifications of the major customers (where such specifications exist);

3. Assess the seasonal effect on meat quality of product supplied to the food service industry; and

4. To objectively measure the pH, meat colour and area, fat colour and area and percentage of marbling, by the use of a pH meter and the Video Image Analysis (VIA) equipment.

Product included in this audit was sourced from normal commercial production supplied to the above sectors of the food service industry. Product from the Aus-Meat cipher categories of "A", "S", Prime, Young and Yearling were sourced from 36 processor establishments numbers over a 15 month period. Objective measurements by Video Image Analysis and pH meters were used to assess all the product tested.

6.3 METHODOLOGY

The methodology used in this audit project focuses on the commercial wholesale throughput of beef fillet steaks used in the domestic food service industry.

Although the establishment numbers were identified, the aim was to assess the variation of beef fillet steaks being supplied to the food service sector, not to compare beef from the various establishment numbers.
The sampling method involved random selection of cartons of beef tenderloins identified for pre-portion preparation on the day of normal commercial production for the food service industry. All tenderloins in the carton sampled were assessed. In extreme circumstances only one carton from an establishment number may have been assessed. The average number of tenderloins assessed per establishment number was 60, or approximately four or five cartons.

Random vacuum packed beef tenderloins were sourced evenly over a four week period, at three monthly intervals, from commercial production and procedures from February

1994 to February 1995 inclusive. Samples were identified by Aus-meat cipher category, establishment number, date of packaging, date of sampling, weight category and whether grain or pasture fed. All tenderloins were sourced with the M. Psoas Minor off and individually wrapped, in which all samplings were carried out in a commercial premises the temperature of the room was set at 10°C.

Beef tenderloins were weighed and measured for length when first taken from the vacuum packaged bag. A fillet steak approximately 100 to 150 grams (commercial weight for airline catering) was taken from the centre of the tenderloin. This steak was weighed and pH measured using a Jenco Model 6007 micro computer based portable pH meter and an Ionode meat probe IJ42. the pH reading is temperature compensated. After blooming (exposing the meat to oxygen) for 20 to 40 minutes the fillet steak was assessed for total area, meat area, marbling area, fat area, the dimensions of diameter, perimeter and width, the meat and fat colour assessments of red, green, blue, hue, saturation and intensity, the Ausmeat meat, fat and marbling scores and the marbling and fat percentages using the Video Image Analysis equipment developed by the Meat Research Corporation of Australia. The subjective assessments of texture and firmness were also recorded using a 1 to 6 scoring system, whereby a score of 6 coincided with a firm very fine texture, 5 = firm fine texture, 4 = medium/fine texture and medium firmness, 3 = medium/coarse texture with medium firmness, 2 = coarse texture and soft firmness and 1 = very coarse texture and soft firmness. The score given equates to the lowest of the texture and firmness scores. This assessment was carried out by Assessor No. 1 in February 1994 and May 1994, Assessor No. 2 also assessed May 1994 and then assessed August 1994, November 1994 and February 1995.

6.3.1 Statistical Analysis

Systat V5.03 has been used to perform all the statistical analysis. The aim of this section is to give a brief overview of the statistical procedures used.

T-Tests

The t-test has been used in the case where there are two groups (for example, grainfed versus pasturefed). The question being asked is whether there is a difference in the various attributes between these groups. For example, is there a difference in the pH measurement between grainfed and pasturefed products?

The t-test compares the means of the two groups of cases. This method is based on the assumption that the two groups have equal variances. There is some leeway in this assumption when sample sizes are large (30 cases is usually considered as large). Systat prints out a "pooled variances t-test" and a "separate variances t-test". The latter is appropriate when the equal variances assumption has been violated. Only the relevant "t-test" has been included in this report.

If there is a difference between the two groups of cases, the "PROB" value will be below 0.01. If the "PROB" is above this figure, there is no statistical evidence to show that there is a difference.

Analysis of Variance

Analysis of Variance (ANOVA) is an extension of the "t-test". Instead of testing just two groups, ANOVA is used when the difference (if any) is being analysed between many groups - such as establishment numbers, ciphers etc. The underlying assumption of this procedure is that the population distributions are normal with equal variances. This assumption has been verified before the test was applied. If there is a difference between populations, the "P" value will be below 0.01. If this is the case, a "post hoc"

test has been applied to ascertain where the differences lie. ANOVA merely tells if there is a difference, but post hoc (Tukey HSD) will detail where the differences are. The post hoc results have not been included in the report as the "Bar Graph" usually displays the same information.

Due to initial differences found between Aus-meat Meat ciphers and sample numbers, each cipher was analysed individually to ascertain differences between establishments and month of testing.

Bar Graphs

The Bar Graph shows the average of a particular attribute grouped according to the establishments, month etc. A line above each bar in the graph shows the standard deviation about the mean for the particular group.

The Bar Graph has been included in the report where it was found that there were differences in attributes between groups.

Contingency Tables

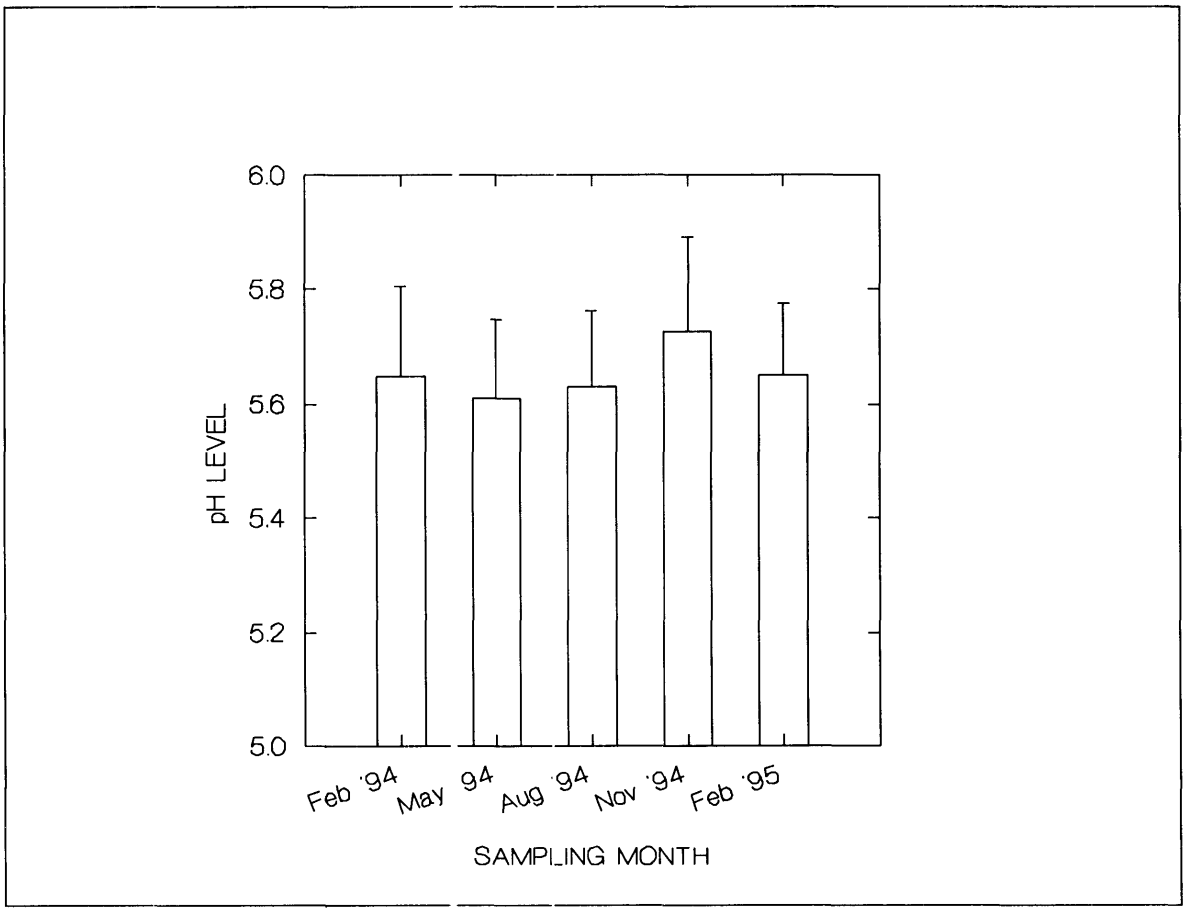
This test will investigate whether a relationship exists between two categorical variables by using the chi-square test statistic. For example, whether there is a difference in the reasons why samples did not meet specification between the grainfed and pasturefed product. The principal behind this statistical procedure is to compute what is expected for each frequency within the table under the assumption of independence. The Pearson chi-square statistic is a way of measuring the departure of the observed frequencies from the expected frequency. Systat will printout a "PROB" statistic. If this value is below 0.01, at 99% confidence it can be concluded that the categorical variables are NOT independent.

6.4 RESULTS

6.4.1 pH

The mean pH of all beef supplied to the food service industry in this study was pH 5.64 with a minimum pH of 5.38, maximum pH of 6.61 and standard deviation of 0.14. Graph 6.1 illustrates changes in mean pH levels over time. On a seasonal basis November 1994 had the highest mean and standard deviation of 5.73 and 0.17 respectively, while the lowest mean pH of 5.61 occurred in May 1994 with a standard deviation of 0.14.

Graph 6.1: Mean pH Values For Each Sampling Period.

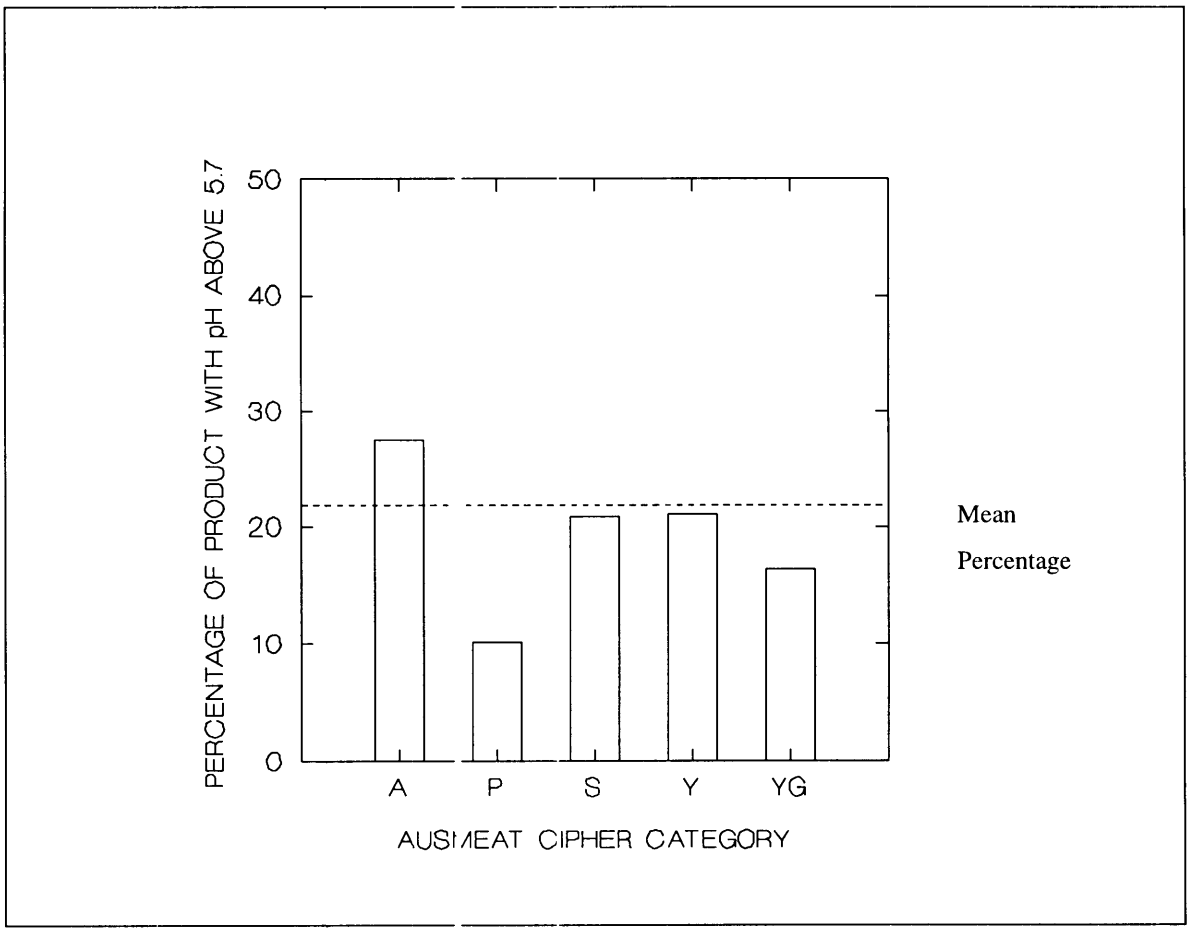


There was a significant difference in the pH between the "A" Aus-meat cipher category

and the "P", "S", "Y" and "YG" c pher categories, 5.66, 5.60, 5.63, 5.64 and 5.63 respectively ($P<0.01$).

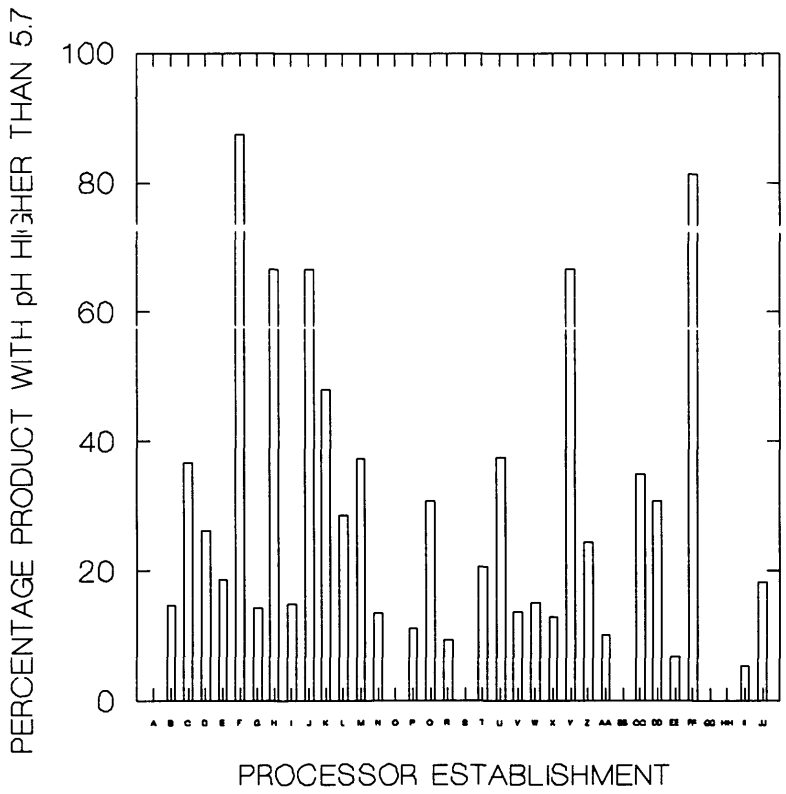
The most endorsed food service ir dustry specification of pH is for a maximum pH of 5.7. 22% of all beef assessed was above a pH level of 5.7 with 2.7% of beef above 6.0 pH. Graph 6.2 illustrates the perce ntage of product with pH greater than 5.7 for each AUS-MEAT Cipher category.

Graph 6.2: Percentage of product with pH more than 5.7 for each AUS-MEAT cipher category



There are however two establishments that met the pH specification 100% using "A" cipher product. Across all cipher categories, the variation in meeting the pH specification ranged from 100% to 12.5%. Graph 6.3 illustrates the percentage of product with pH higher than 5.7 for each processor.

Graph 6.3: Percentage of Product with pH higher than 5.7 for each Processor.



As expected, there was a large variation in processor establishment mean pH levels with three establishments averaging over pH 5.8.

There was no difference in pH of grain fed or pasture fed product (P>0.05).

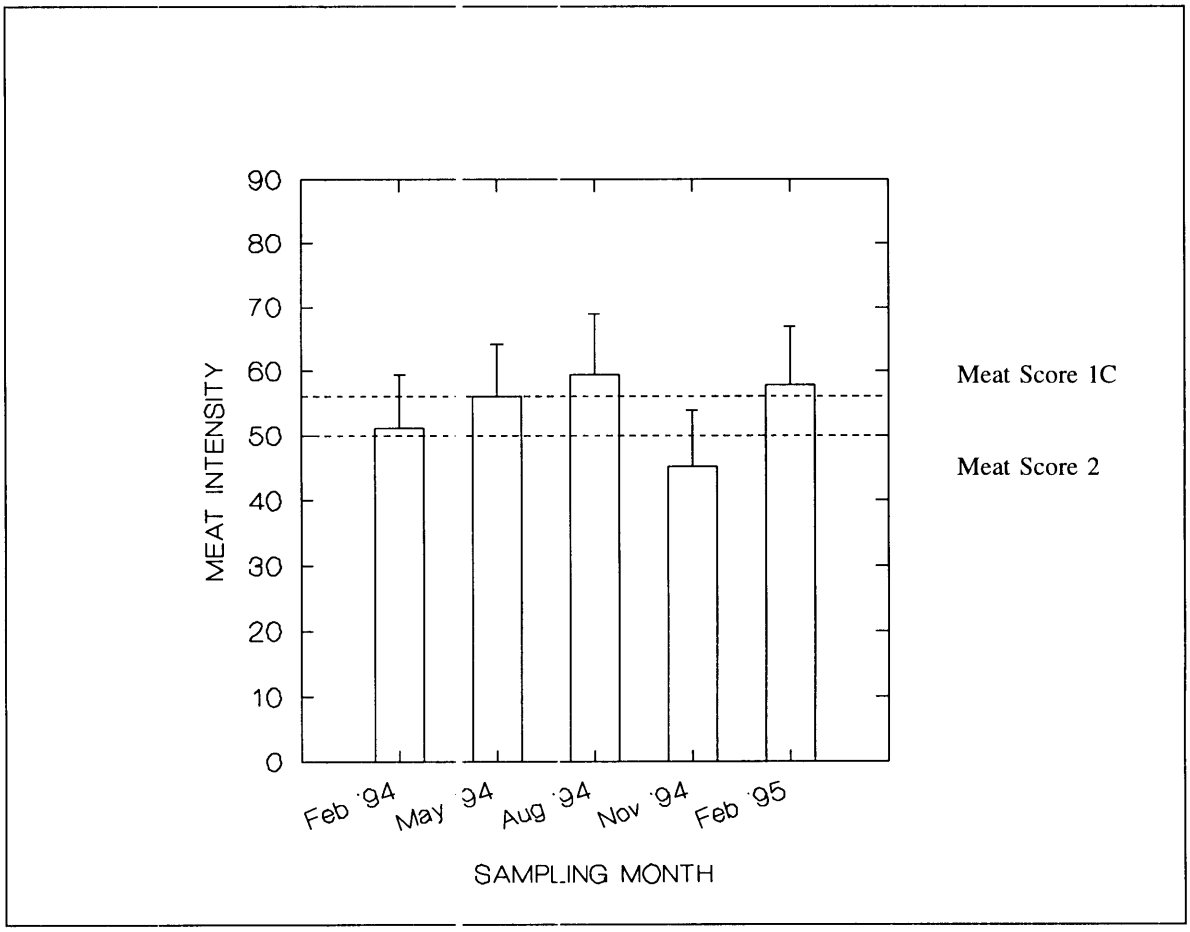
6.4.2 Meat Colour

The Meat Colour measurement was taken as the meat intensity score measured using the Video Image Analysis Assessment equipment. The meat intensity score is the red, green and blue values added together and divided by 3. The meat intensity score is the V.I.A. measurement that equates to the Aus-meat Meat Colour Score. The widely used food service specification for meat colour is 1A to 3, or meat intensity score above 47.

The mean meat intensity score of all beef sampled was 55.5 which is the cut-off between an Aus-meat Meat Colour Score of 2 and 1C, with a standard deviation of 9.6. The maximum meat intensity score was 90.1 (top end of an Aus-meat Meat Score 1B) and the minimum meat intensity was 25.0 or an Aus-meat Meat Score of 9 (darkest Aus-meat Meat Score).

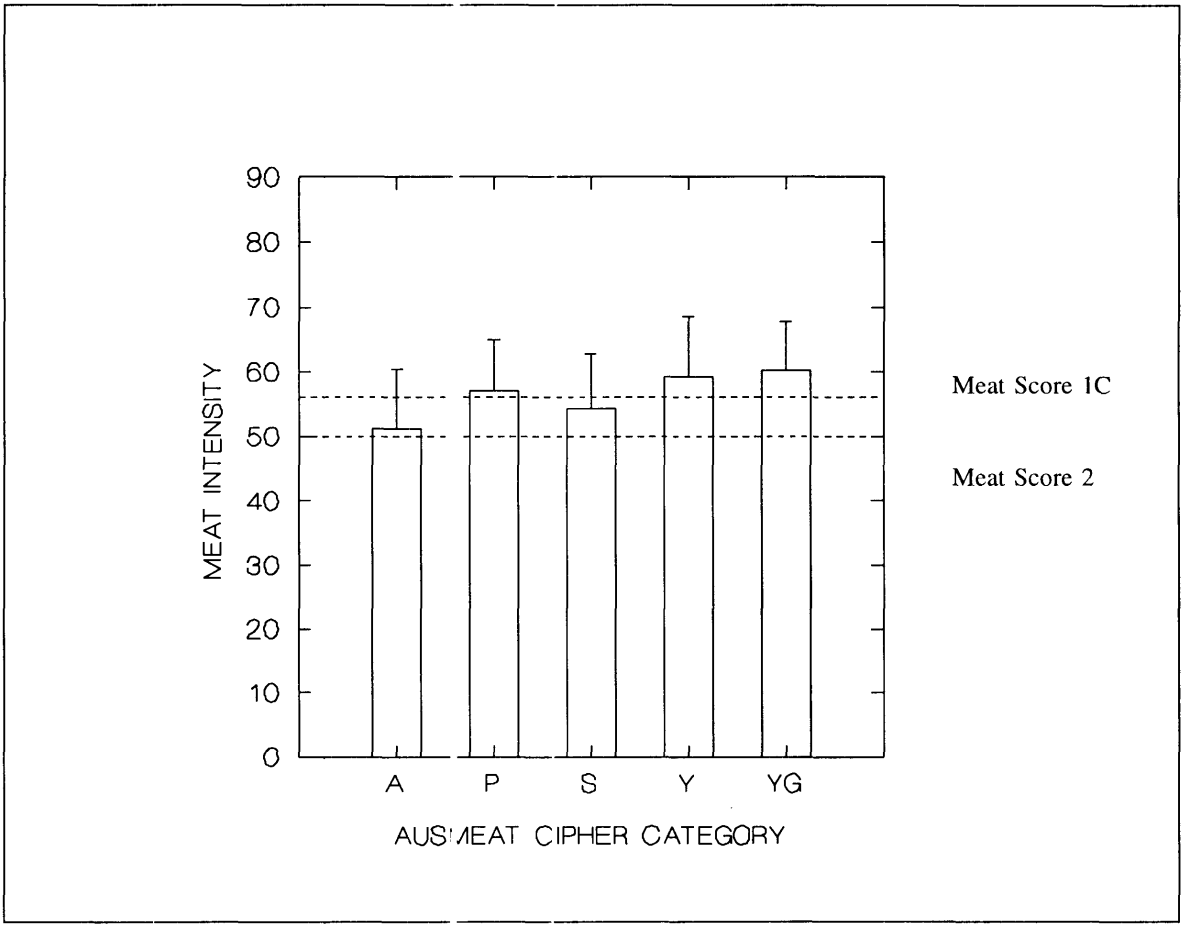
Seasonal assessments indicated that lower meat intensity scores occurred in February 1994 and November 1994, Graph 6.4.

Graph 6.4: Mean Meat Intensity Values For The Various Sampling Months



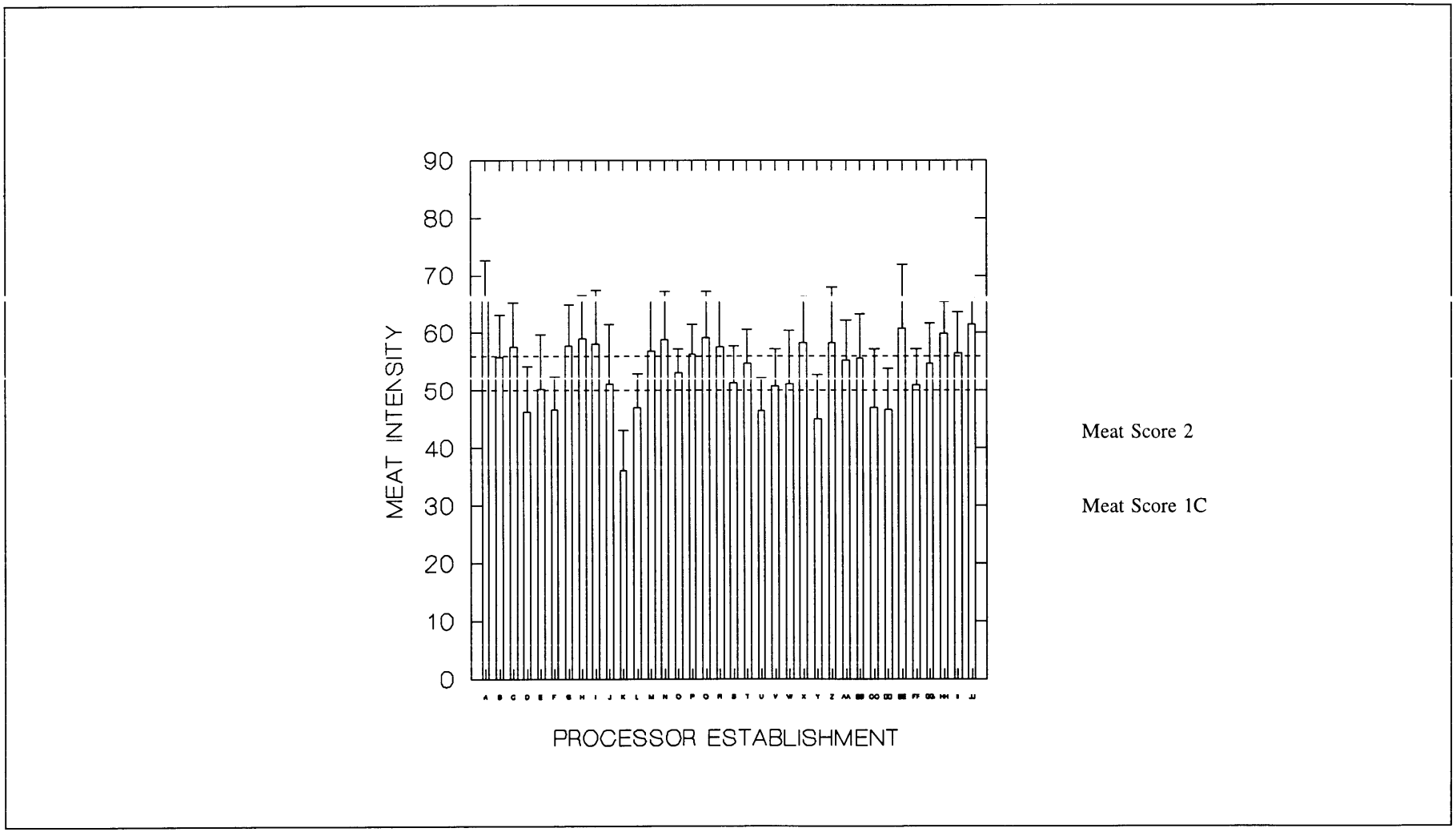
Aus-meat cipher categories significantly affected the meat colour with "A" and "S" ciphers averaging an Aus-meat Meat Colour Score of 2 and the "P", "YG" and "Y" cipher categories averaging a 1C (P<0.01), Graph 6.5.

Graph 6.5: Difference in Meat Intensity between each Aus-Meat cipher category



As expected, there was a large variation in meat intensity scores between the various processing establishments (P<0.01). The maximum meat intensity mean for a processing establishment was 66.1 (Aus-meat Meat Colour Score 1B) at establishment "A" and the lowest meat intensity mean was 36.1 (Aus-meat Meat Colour Score 7) from establishment "K", Graph 6.6.

Graph 6.6: Difference in Meat Intensity between processor establishments



There was a significant difference between meat intensity scores of grain fed product and pasture fed product with scores of 59.0 (Aus-meat Meat Colour Score 1C) and 54.7 (Aus-meat Meat Colour Score 2) respectively (P<0.01).

6.4.3 Texture and Firmness

The subjective assessment of texture and firmness is explained in the methodology. Although the texture and firmness score is the only subjective assessment in this report, it has been included as it is an important specification requirement for those food service companies reported in Chapters 4 and 7.

The texture and firmness of meat are important visual characteristics for the food service industry and their consumers, the efficiency of cutting yields of pre-portioned product and the accuracy for the consumers' degree of doneness to be achieved. For example, if one side of a steak is soft and thin, then this will cause uneven display and cooking to the required degree of doneness.

A texture/firmness score 4 equates to the texture/firmness specifications used in the M.R.C. Marketlink Program companies.

The mean texture/firmness score for all the beef tested was 4.4 with a standard deviation of 1.0, a maximum score of 6 and minimum score of 1 (lowest possible).

The Aus-meat cipher category "A" was significantly coarser in texture and softer in firmness than the "P", "S", "Y" and "YG" cipher categories, 4.0 and 4.9, 4.6, 4.6 and 4.7 respectively (P<0.01).

The percentage of product meeting the endorsed food service industry specification was 90%, however the range of establishments meeting this specification ranged from 100% to only 59%.

There was a small significant difference in the texture and firmness scores favouring the

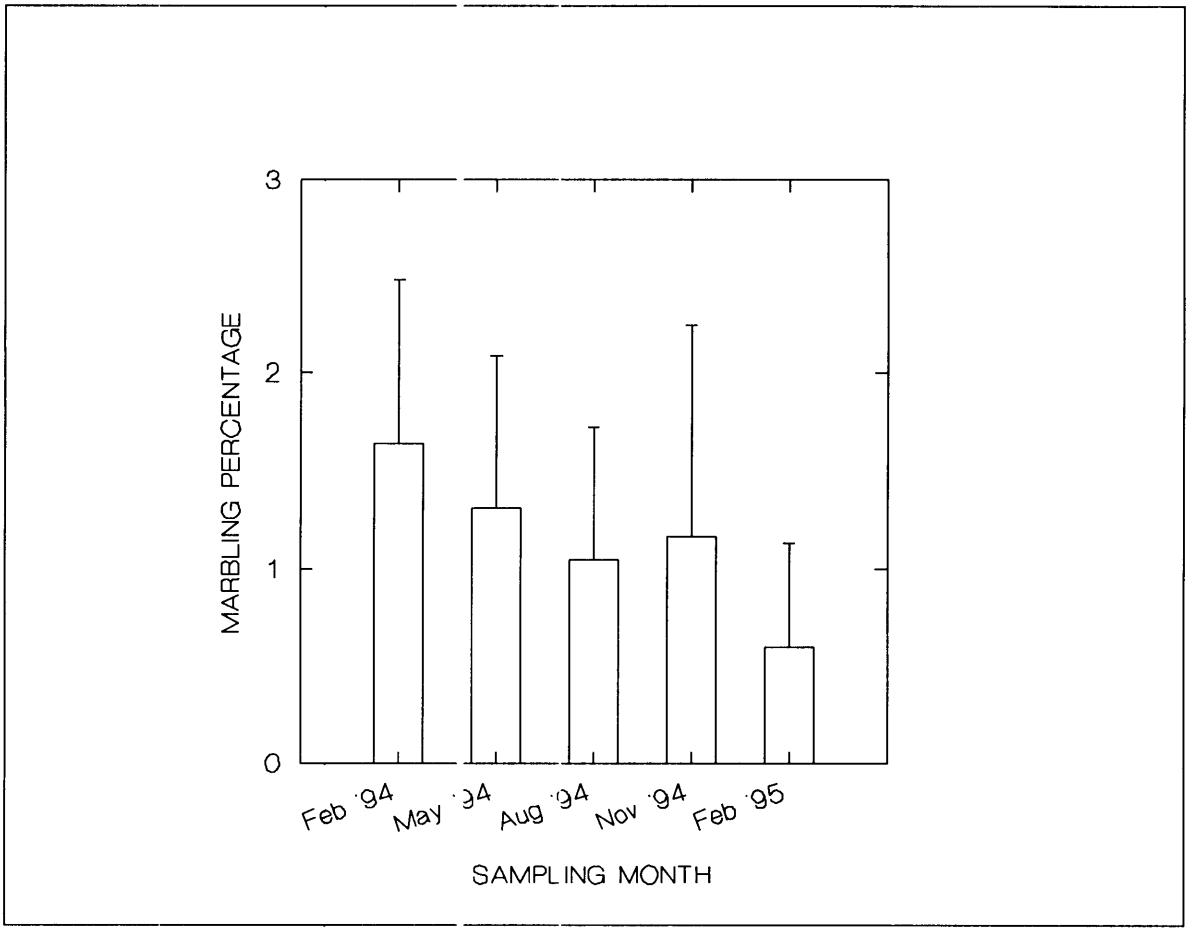
grain fed over the pasture fed product, with means of 4.6 and 4.3 respectively ($P<0.01$).

6.4.4 Marbling

The marbling is assessed using the visual marbling percentage of the V.I.A. equipment. The mean marbling percentage for all beef tenderloins assessed for the food service industry was 1.1% with a very large standard deviation of 0.8. The maximum and minimum marbling percentage was 7.0% and 0.0% respectively. The mean marbling percentage was equivalent to an Aus-meat Marbling Score of 1 (traces), however the large standard deviation demonstrates the large variation of marbling in the samples assessed.

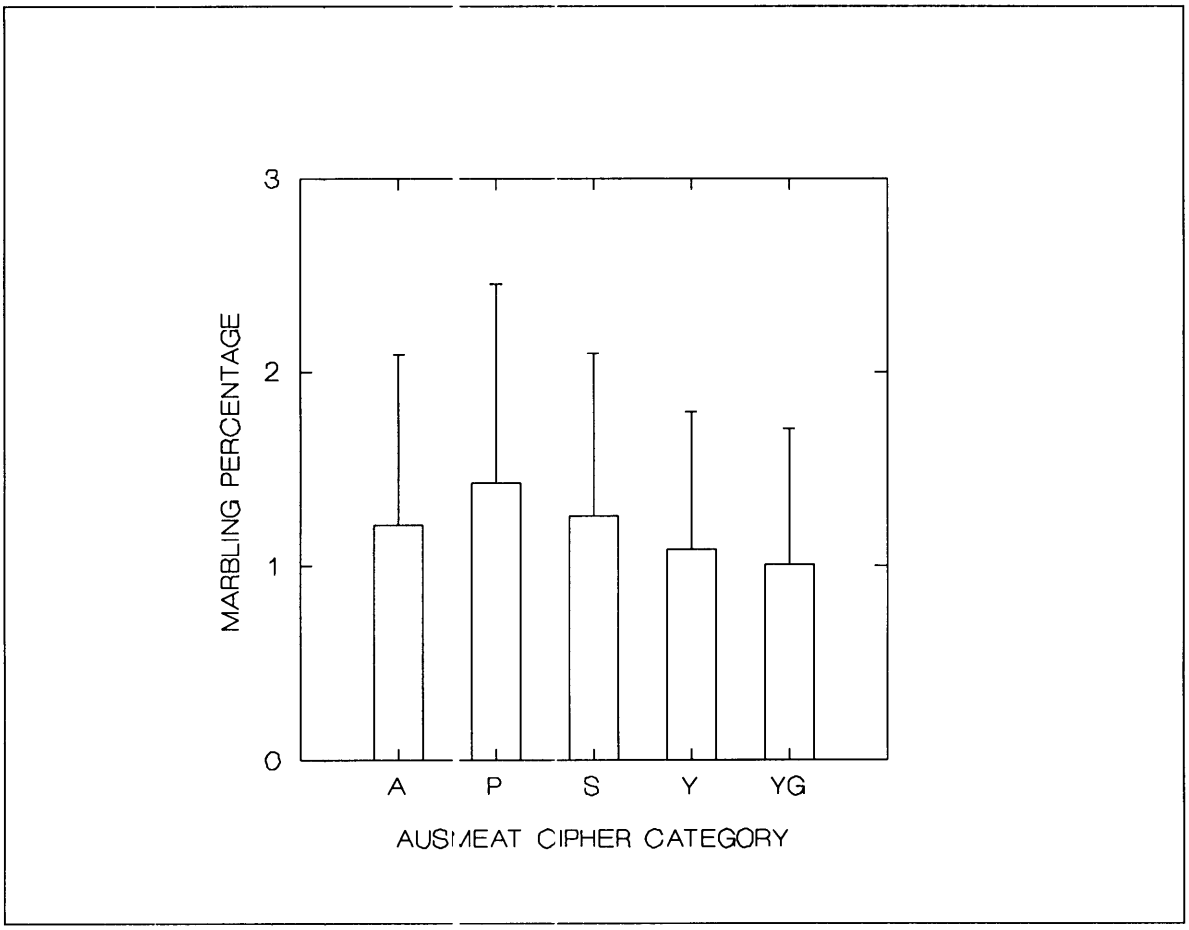
The decline in marbling percentage over the time frame of this audit was significant and is graphically presented in Graph 6.7. This was most likely due to the continuing drought conditions across eastern Australia over the duration of the audit.

Graph 6.7: Difference in Marbling Percentage between sampling months



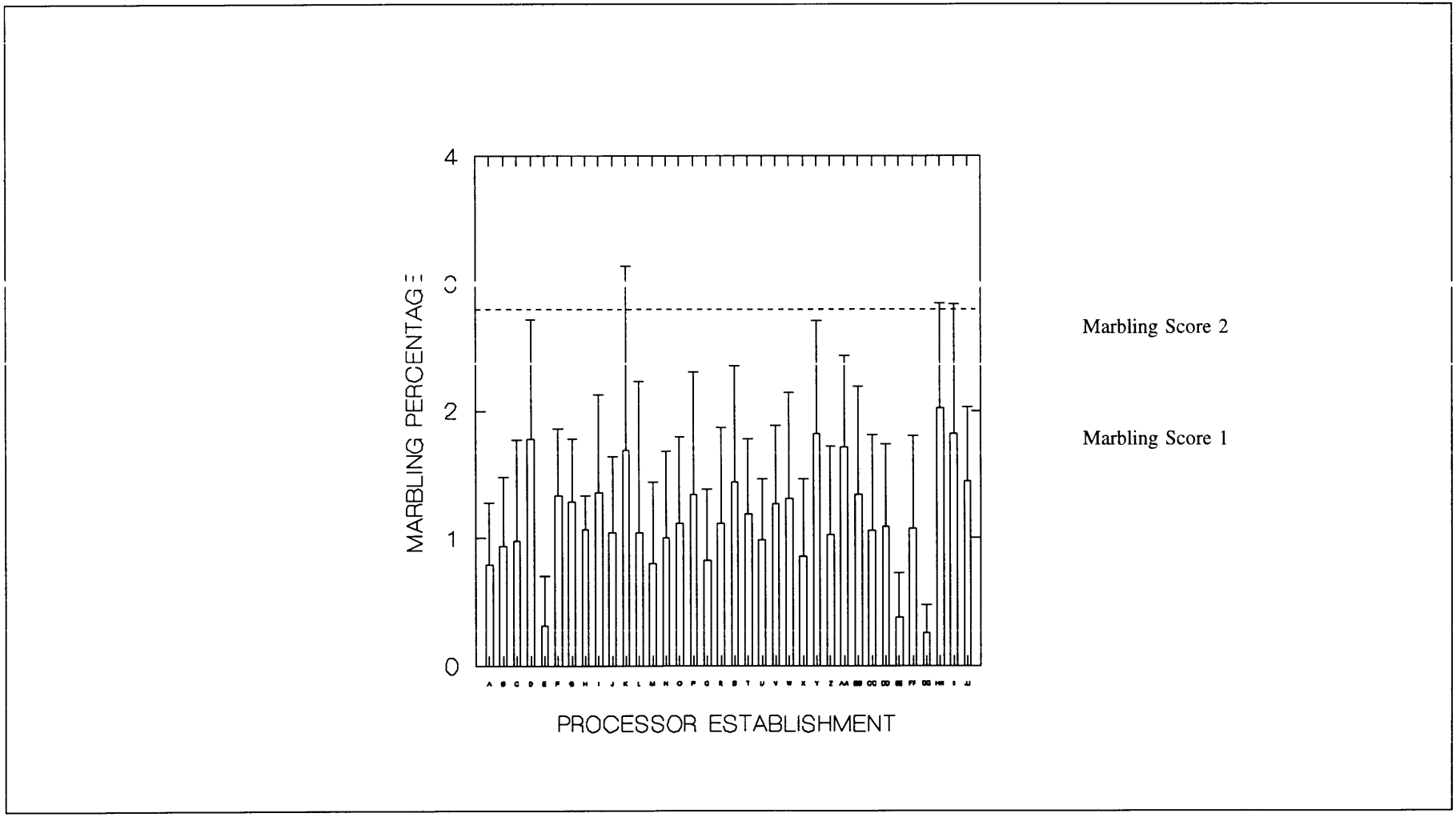
The "P", "S" and "A" Aus-meat cipher categories had significantly higher marbling percentage than the "YG" cipher category, with percentages of 1.4%, 1.2%, 1.2% and 1.1% respectively (P<0.01). The "P" and "S" cipher categories had significantly higher marbling percentages than the "Y" cipher (1.1%) also (P<0.01), Graph 6.8.

Graph 6.8: Difference in Marbling Percentage between each Aus-Meat cipher category



The variation in marbling percentage between processor establishment numbers ranged from mean percentages of 0.3% up to 2.0% marbling, graph 6.9. 4.2% of beef tenderloins assessed had a marbling percentage above 2.8% or Aus-meat Marbling Score of 2 (D. Barrett-Leonard, pers. com.).

Graph 6.9: Difference in Marbling Percentage between processor establishments



Pasture fed beef tenderloins had small but significantly more marbling than grain fed beef tenderloins supplied to the food service industry, 1.2% and 1.0% respectively ($P<0.01$).

6.4.5 Meeting Food Service Industry Specifications

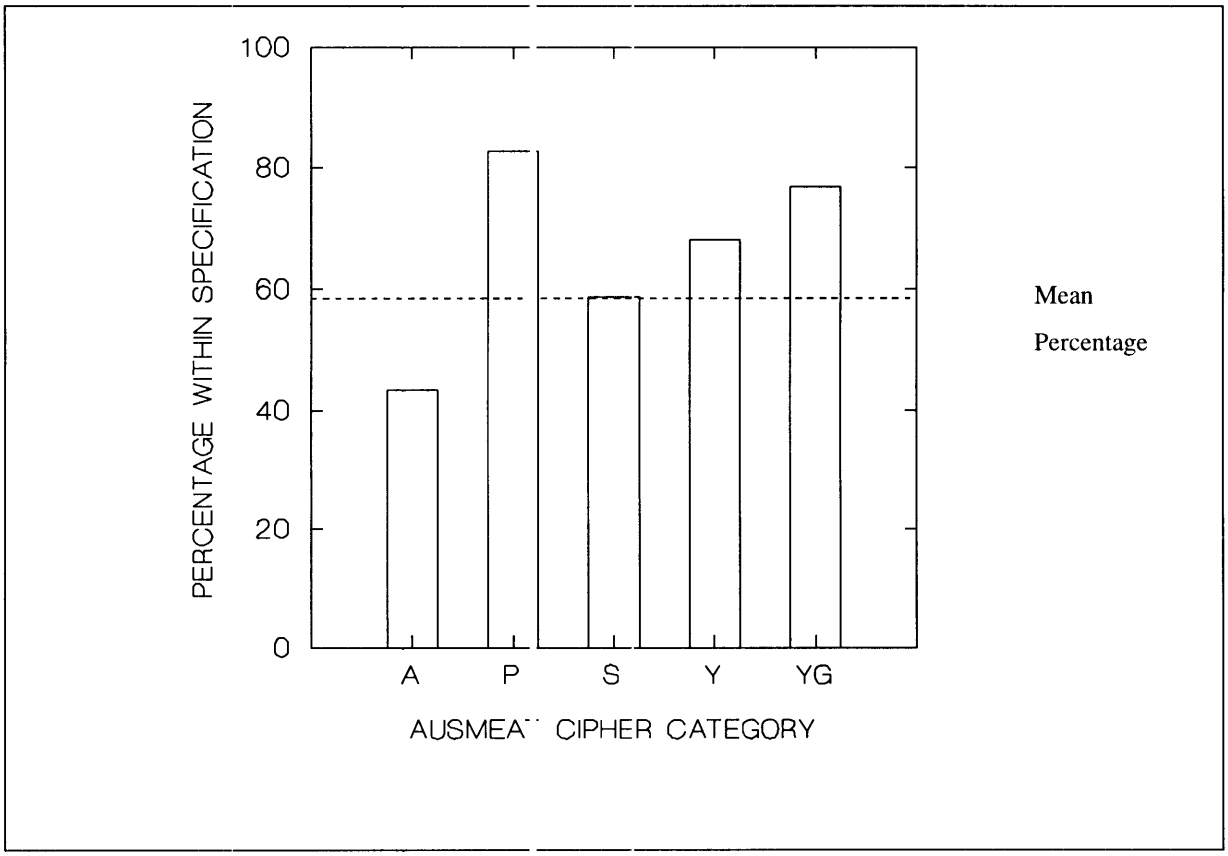
Specifications for the food service industry have been virtually non existent until three years ago. Up to this date, the majority of specifications related to portion size, weight, price and the ability of the wholesaler to source suitable product for the food service outlet. Over the last three years, there has been a major effort by Aus-meat and individual companies to tighten up their specifications and make them more accurate in meeting their consumers' satisfaction requirements. The following beef tenderloin specification is used by many of the major food service companies, e.g. Qantas, Sizzler

Meat Colour:	1A	-	3
Marbling Score:	1	-	3
pH:	5.35	-	5.7
Texture/Firmness:	4	-	6

The analysis assessed in order:- pH, Meat Colour and Texture/Firmness. The order of analysis means that if the sample was out of specification for pH it was then not included in those out of specification for Meat Colour. Therefore, the amount of product out of specification on Meat Colour and Texture/Firmness would be higher when assessed as single traits.

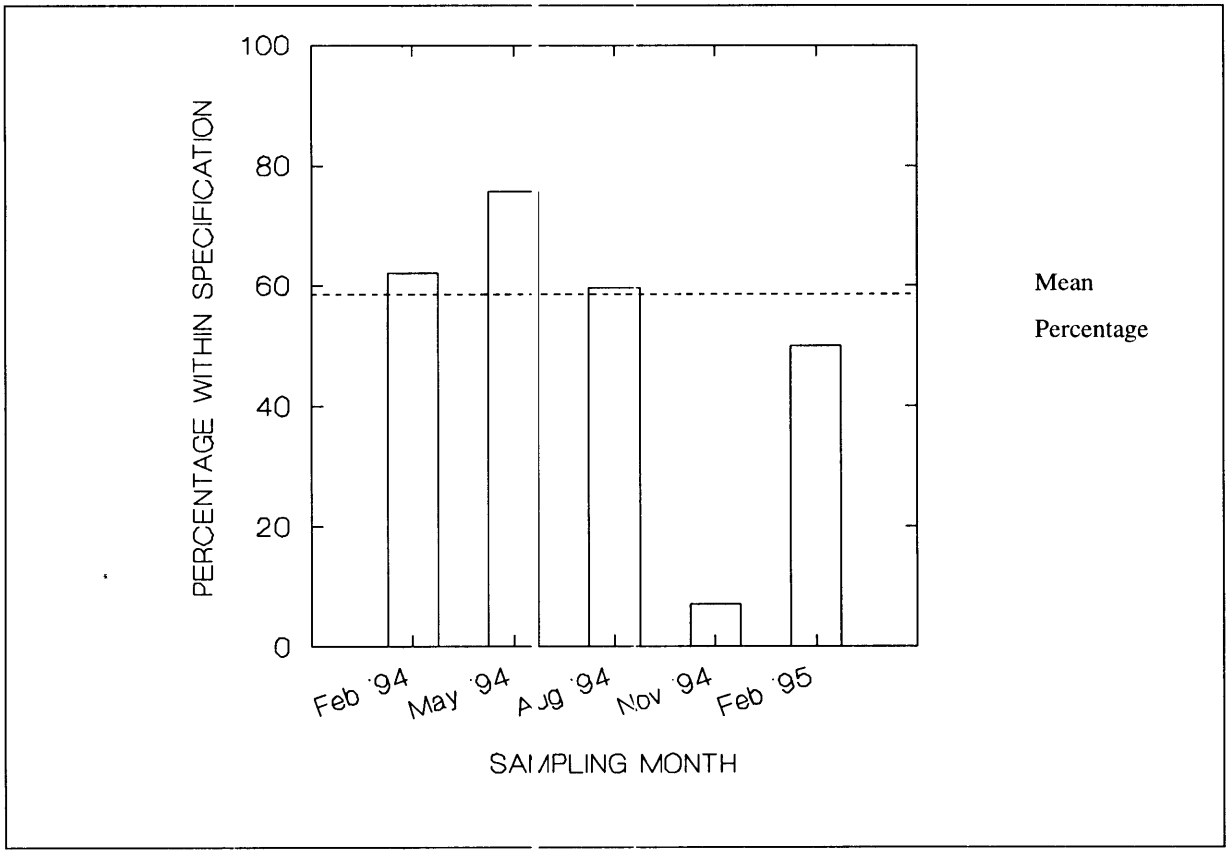
58.5% of all beef tenderloins asse ssed met the above specification, however this varied considerably between the "P", "YG", "Y", "S" and "A" AUS-MEAT cipher categories with 83%, 77%, 68%, 59% and 43% respectively (P<0.01), Graph 6.10.

Graph 6.10: Percentage of product within specification for each Aus-Meat cipher category



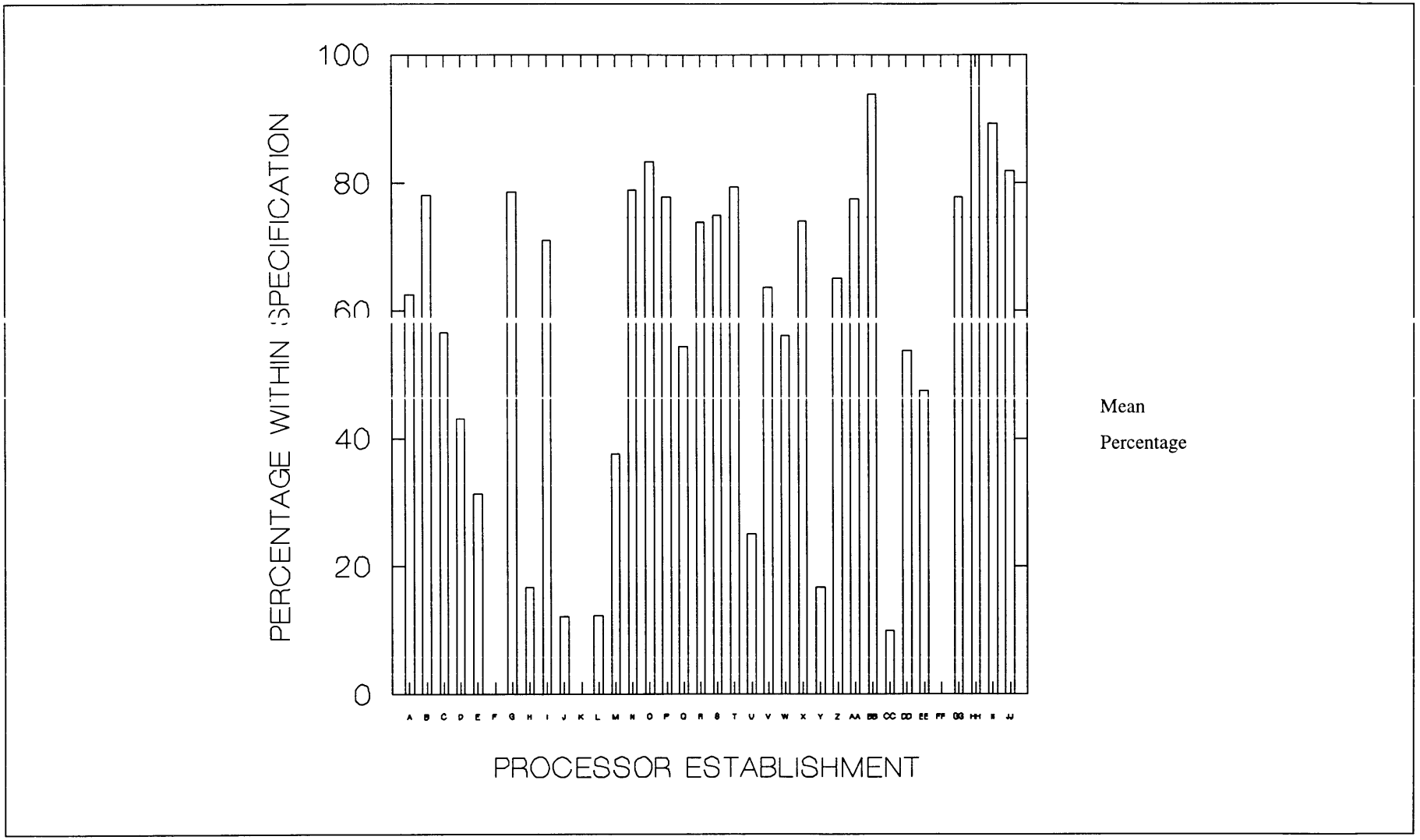
The variation in product meeting the specification over the duration of the audit is included in Graph 6.11. The very low percentage of beef tenderloins meeting the specification in November 1994 may be due to the lower sample numbers over this period and the poor results from those companies assessed.

Graph 6.11: Percentage of product within specification for each sampling month



A total of 16 processor establishment numbers assessed supplied over 70% of their product that met the specification, while four processor establishment numbers had none of their product meeting the above specification, Graph 6.12.

Graph 6.12: Percentage of product within specification for each processor establishment



Overall 9.5% of product failed to meet the specification on meat colour with 10% and 22% failing on texture/firmness and pH respectively.

There was a significant difference between grain fed (67%) and pasture fed (57%) meeting the specification (P<0.01). This 10% advantage in consistency of meeting the specification for grain fed product is illustrated in table 6.1.

Table 6.1: Difference in Product Meeting Specification between Grainfed and Pasturefed

SPECIFICATION	GRAINFED	PASTUREFED	OVERALL	N
In Specification	66.7%	56.6%	58.5%	1248
Out on pH	24.5%	21.2%	21.9%	466
Out on Meat Colour	3.4%	11.0%	9.5%	202
Out on Text/Firm	5.5%	11.2%	10.1%	215
TOTAL	100%	100%	100%	
N	417	1715	2132	
TEST STATISTIC	VALUE	DF	PROB	
PEARSON CHI-SQUARE	38.909	4	0.000	

6.4.6 Total Weight and Length of Beef Tenderloins

The mean weight of all beef tenderloins assessed was 1398 grams with a standard deviation of 291 grams. The maximum and minimum weights were 2955 grams and 485 grams respectively.

The mean weight of beef tenderloins in February 1994 and 1995 was significantly lighter than August 1994, 1370 grams, 1360 grams and 1455 grams respectively ($P<0.01$). All other differences were not significant. Significantly heavier beef tenderloins occurred between the Prime, 'S" and Young AUS-Meat cipher categories and the "A" and Yearling cipher categories, 1562 grams, 1612 grams, 1508 grams and 1375 grams and 1153 grams respectively ($P<0.01$), .

The mean length of a beef tenderloin assessed was 59cm with a standard deviation of 5.4cm and maximum and minimum length of 81cm and 24cm respectively. "A" cipher beef tenderloins are longer than the"S", "P", "YG" and "Y" AUS-Meat cipher categories, the length also increased with age, 62 cm, 60 cm, 58cm, 57 cm and 52cm respectively ($P<0.01$).

The grain fed product was significantly lighter in weight and shorter in length to the pasturefed product, 1371 grams and 54 cm. and 1404 grams and 59 cm.($P<0.05$ and $P<0.01$) respectively.

6.5 DISCUSSION

The results of this quality audit illustrate the large variation of beef tenderloins being sourced for the food service industry. These variations range from pH values of 5.38 to 6.61, meat intensity colour values of 25 to 90 (AUSMEAT meat colour score 9 to 1B), texture and firmness scores of 1 to 6 (minimum and maximum scales), marbling percentages of 0% to 7%, weights of 485 grams to 2955 grams and lengths of 24cm to 81cm.

While it is acknowledged that a number of food service outlets place a lot of emphasis on price as a factor for purchase, this audit illustrates that nearly the full spectrum of product within each assessed category was sourced for this industry.

This variation demonstrates the lack of understanding the supplier (in this case the

processor) has on the affect these traits have on consumers satisfaction levels.

Because of the high percentage of pH values above 5.7 (22%), this would indicate a large degree of variation would occur in the delivered degree of doneness scores to consumers (see Chapter 5).

With 22% of beef tenderloins failing to reach a common food service pH standard, all product should be assessed before preportion preparation or departure from the processor.

It is of interest to note that while there was no difference between the pH levels of grain and grassfed product sampled there was a significant difference between these products for the colour assessment of meat intensity.

The age effect on marbling are similar to those reported by Lawrie (1991), with marbling percentage increasing in older animals.

Because of the high percentage of AUSMEAT cipher "A" category (57%) failing to reach a common food service specification, this cipher category should not be sourced for the food service industry, or only "A" cipher category product that has been chiller assessed be allowed to be sourced.

Due to the drought conditions prevalent over eastern Australia during this audit period, some of the assessments taken may not be representative of samples sourced over a normal year.

6.6 CONCLUSION

The variation in product sourced for the food service industry illustrates where a large proportion of consumer dissatisfaction may come from. All sectors of the beef value chain must be aware of the consequences poor quality and consistency play in not

delivering desired levels of consuıners satisfaction. Consumers have a wide variety of protein sources to balance diets, give variety to meats and deliver a variety of taste sensations. It is up to the beef valıe chain to only source product that meets consumer's satisfaction requiremeıits.

6.7 Appendix 1: Aus-meat Cipher Categories Used In The Quality Audit

A (beef) Category: Female or castrate or entire male bovine that:
- In the case of males, shows no evidence of secondary sex characteristics (SSC).

Y (Yearling beef)
Category: Female or castrate or entire male bovine that:
- Shows no evidence no evidence of eruption of permanent incisor teeth.
- In the case of males, shows no evidence of SSC.

YG (Young beef)
Category: Female or castrate or entire male bovine that:
- Shows no evidence of eruption of more than two permanent incisor teeth.
- In the case of males, shows no evidence of SSC.

P (Prime beef)
Category: Female or castrate or entire male bovine that:
- Shows no evidence of eruption of more than seven permanent incisor teeth.
- In the case of males, shows no evidence of SSC.

S (Ox): Female or castrate or entire male bovine that:
- In the case of females, shows no evidence of eruption of more than seven permanent incisor teeth.
- In the case of males, shows no evidence of SSC.

Chapter 7: THE EFFECT OF CONSUMERS PERCEPTION OF DEGREE OF DONENESS ON SOME BEEF PALATABILITY TRAITS, VALUE FOR MONEY AND REPURCHASE INTENT WITHIN THE FOOD SERVICE INDUSTRY.

7.1 INTRODUCTION

The ability to deliver customer satisfaction that maintains customer loyalty and increases patronage is a very complex issue facing the food service industry.

Where beef products are offered on menu items, nearly all emphasis to improve customer satisfaction has been directed to developing new beef dishes, or improving the tenderness, juiciness, flavour and aroma of the beef, by using quantifiable purchasing specifications and quality assurance programs to improve these attributes and deliver a consistent product.

Research has also focussed on improving these attributes and in particular tried to develop objective technology to identify those products with superior attributes. This research focus has lead to discrepancies between objective technical scientific results and those consumer perceptions for the same attribute(Chrystall, 1994).

Trained sensory panels have been set up to subjectively measure these palatability attributes, while giving a perceived consumer focus. However, the correlations between sensory panellists and palatability attributes or consumer acceptance levels is variable (Gracula, 1987; McBride and Finlay, 1989).

Lyon et al., (1986), described the ideal process for cooking dry-roasted beef, as requiring a fine balance between heating to hydrolyse collagen, minimum heating to obtain rare colour and minimise myofibrillar toughening and maximum heating to ensure reduced microbial activation. For restaurants/institutional markets it also requires maintaining colour quality that consumers associate with degree of doneness preferences.

The degree of doneness research to date has focussed on the causes of variation (Lyon et al.,1986; Trout, 1989; Cornforth et al., 1993; Cox et al., 1994) not on the affect consumers perception for degree of doneness has on palatability traits and how in a commercial environment this affects consumers satisfaction, value for money and repurchase intent.

The Meat Research Corporation of Australia, has initiated a strategic alliance with leading food service companies (from fine dining through to institutional catering outlets), using best practice principles and procedures to identify customers satisfaction and repurchase requirements and communicate these through feedback and partnership agreements to all members of the value chain.

7.2 METHODOLOGY

Consumers of four food service companies were surveyed at 10 restaurants and catering outlets from September 1994 to May 1995.

Three thousand seven hundred and eighty (3,780) consumers who selected beef menu items were surveyed at the point of consuming their meals. Consumers filled out the survey forms themselves after a brief explanation of the survey format by trained interviewers. The number of consumers surveyed per site varied from 54 to 588, with a mean of 378. Surveyed consumers were representative of normal commercial customers visiting

these restaurants and catering outlets over the survey period.

The survey included questions which were answered using an intensity scale with relative wordings for each cluster point, scored on a 1 to 6 basis or an intent to purchase scale described by Love, (1994)

Consumers were given a choice (word only) for five degrees of doneness. These were rare, medium/rare, medium, medium/well done and well done. Consumers were also grouped into age clusters of under 18 years, 18-29 years, 30-39 years, 40-54 years and over 55 years of age. Consumers were further classified by their attitude towards beef. The four classifications were: Appreciator - I enjoy beef well enough it is an essential part of our diet. Acceptor - I enjoy beef well enough, it is a regular part of my diet. Resistor - I do eat some beef, although truthfully it would not worry if I didn't. Rejector - I rarely/never eat beef.

The beef meals included preportioned beef tenderloin (238), striploin (190), cube roll (409) and rump (2651) steaks and roast "rostbiff" rump beef (225). All primal beef cuts were sourced from commercial specifications requiring that steers and females have less than seven permanent incisor teeth, all product was vacuum packaged and aged for a minimum of 14 days.

All beef steaks and roasts were cooked by chefs and cooks employed by the relevant companies, using normal commercial cooking practices and procedures. Normal commercial practices were implemented to cook all steaks to the customers requested degree of doneness. However in the case of roast beef, all meals were cooked as medium / well done by qualified chefs.

The preferred and delivered degree of doneness scores for steaks and roast beef reported are those of the consumer only. No attempt was made to explain a definition of degree of doneness to the consumer. The assessment of whether the beef

was cooked to the right under or over degree of doneness was solely the choice of the consumer and represents their perception of degree of doneness, not that of a chef / cook or temperature assessment.

7.2.1 Statistical Analysis

Systat V5.03 has been used to perform all the statistical analysis. The aim of this section is to give a brief overview of the statistical procedures used.

T-Tests

The t-test has been used in the case where there are two groups (for example, males versus females). The question being asked is whether there is a difference in the various attributes between these groups. For example, is there a difference in the sensory scores between males and females?

The t-test compares the means of the two groups of cases. This method is based on the assumption that the two groups have equal variances. There is some leeway in this assumption when sample sizes are large (30 cases is usually considered as large). Systat prints out a "pooled variances t-test" and a "separate variances t-test". The latter is appropriate when the equal variances assumption has been violated. Only the relevant "t-test" has been included in this report.

If there is a difference between the two groups of cases, the "PROB" value will be below 0.01. If the "PROB" is above this figure, there is no statistical evidence to show that there is a difference.

Analysis of Variance

Analysis of Variance (ANOVA) is an extension of the "t-test". Instead of testing just two groups, ANOVA is used when the difference (if any) is being analysed between many groups - such as degree of doneness, whether cooked right or under/over

cooked etc. The underlying assumption of this procedure is that the population distributions are normal with equal variances. This assumption has been verified before the test was applied. If there is a difference between populations, the "P" value will be below 0.01. If this is the case, a "post hoc" test has been applied to ascertain where the differences lie. ANOVA merely tells if there is a difference, but post hoc (Tukey HSD) will detail where the differences are. The post hoc results have not been included in the report as the "Bar Graph" usually displays the same information.

Data has been adjusted to include only those surveys where consumers have responded to both the "ordered" and "delivered" degree of doneness questions.

Regression Analysis

Regression analysis was used to determine whether any relationships existed between the various palatability traits. The following procedure was used:-

1. Graph: The palatability traits were graphed individually against each other. If it appeared that a relationship existed, Step 2 was completed.

2. Regression: This involved fitting a line on the graph to describe the relationship between the variables in question. This "line" may have been linear or curved depending on the results from the graph. If the relationship fitted was significant, "P" value was below 0.01.

3. Assumptions: Residual analysis was conducted to ensure the fitted model adhered to the various assumptions associated with regression analysis.

7.3 RESULTS

7.3.1 Comparison of consumers ordered to delivered degree of doneness

The comparison of ordered versus delivered degree of doneness was classified as: **right**: delivered equalled ordered, **under**: delivered was below ordered and **over**: delivered was above ordered.

The overall consumers ordered, delivered and "cooked right" degree of doneness are reported in table 7.1.

There was a significant difference in the distribution of ordered degree of doneness between the various age groups, ($P<0.05$), whether male or female, ($P<0.01$) and participants attitude towards red meat, with 24%, 29%, 31% and 44% ordering their beef cooked to well done when consumers were classified as "appreciators", "acceptors", "resistors" or "rejectors" respectively, ($P<0.01$).

Table 7.1: Comparison of ordered to delivered degree of doneness.

Degree of Doneness	Ordered Degree of Doneness	Delivered Degree of Doneness	"Cooked Right" Degree of Doneness
Rare	4.3%	5.4%	4.5%
Medium/Rare	19.6%	21.3%	19.5%
Medium	33.2%	28.4%	31.7%
Medium/Well Done	15.1%	20.1%	15.2%
Well Done	27.8%	24.7%	29.2%
Number of Surveys Included	3601	3601	2497 (69%)

The overall distribution for cooked "right", "under" or "over" degree of doneness was 69.3%, 16.9% and 13.8% respectively, ($P<0.01$). There was a significant difference in the percentage of meals cooked "right" between the ten sites, ($P<0.01$), with a range from 64.0% to 86.0% and between age categories, ($P<0.01$). Those under 18 years of age were less likely to receive their delivered equal to their ordered degree of doneness (59.8% vs 65.9% to 78.3% for other age groups).

The percentage of beef cooked right was significantly affected by the consumers attitude towards red meat (appreciator, acceptor, resistor and rejector), with rejectors more likely to assess the beef as undercooked, 31% compared to an overall average of 17%, ($P<0.01$.

7.3.2 The effect of degree of doneness on palatability

The differences between "cooked right", "undercooked" and "overcooked" and the following palatability traits are all significantly different ($P<0.01$), with means for tenderness of 4.5, 4.0 and 3.4; taste 4.6, 3.9 and 3.6; and overall satisfaction 4.5, 3.7 and 3.4 respectively.

Significant differences were found between the "cooked right", "undercooked" and "overcooked" when the taste, tenderness and overall satisfaction scores of excellent/very good and very poor/poor were grouped together, ($P<0.01$), table 7.2.

Table 7.2: Differences between excellent/very good and very poor/poor scores for tenderness, taste and overall satisfaction.

	Cooked Right	Under Cooked	Over Cooked
Taste			
Excellent/ Very Good	53.2%	30.6%	16.1%
Very Poor/ Poor	2.2%	7.7%	12.0%
Tenderness			
Excellent/ Very Good	52.8%	33.3%	19.3%
Very Poor/ Poor	4.7%	11.7%	22.9%
Overall satisfaction			
Excellent/ Very Good	51.1%	33.3%	19.3%
Very Poor/ Poor	3.0%	14.1%	19.6%

All differences were significant for each trait ($P<0.01$)

7.3.3 The effect of degree of doneness on value for money and repurchase intent

In addition to the palatability ratings of taste, tenderness and overall satisfaction, consumers were asked to rate the value for money and repurchase intent of the meal just eaten.

The cooked right value for money mean is significantly higher than under or overcooked, 4.2, 3.5 and 3.3 respectively, ($P<0.01$). The difference between under and overcooked was not significant.

Significant differences were found between the "cooked right", "undercooked" and "overcooked" when the value for money scores of excellent/very good and very poor/poor were grouped together, ($P<0.01$).

The palatability traits of taste, tenderness and overall satisfaction significantly influenced the repurchase intent, ($P<0.01$) table 7.3.

Table 7.3: The effect of taste, tenderness and overall satisfaction on repurchase intent.

Palatability Rating*	Definitely/ Probably Repurchase	Definitely Not/ Probably Not Repurchase
Taste		
Excellent	93.5%	1.7%
Very Good	86.5%	2.4%
Good	70.4%	6.4%
Average	41.0%	21.1%
Poor	19.7%	45.5%
Very Poor	18.2%	59.1%
Tenderness		
Excellent	92.8%	2.1%
Very Good	85.3%	3.3%
Good	72.7%	6.2%
Average	47.8%	15.9%
Poor	26.0%	35.0%
Very Poor	18.5%	53.8%
Overall Satisfaction		
Excellent	94.2%	1.2%
Very Good	89.7%	1.0%
Good	77.9%	3.7%
Average	35.6%	19.0%
Poor	19.0%	45.1%
Very Poor	17.7%	67.8%

* Palatability ratings were on a scale of 1 to 6 with 1=very poor, 2=poor, 3=average, 4=good, 5=very good and 6=excellent.

These palatability traits have a significant influence on consumer's repurchase intent ($P<0.01$)

The mean repurchase intent scores of 4.1, 3.5 and 3.3 for "cooked right", "undercooked" and "overcooked" respectively were significantly different ($P<0.05$).

7.3.4 Correlations

The consumers overall satisfaction is correlated to value for money, ($P<0.01$, $R^2 = 0.447$) and value for money is correlated to repurchase intent($P<0.01$, $R^2 = 0.332$).

The taste and tenderness scores are strongly correlated ($P<0.01$, $R^2 = 0.53$) and this correlation also exists with overall satisfaction, ($P<0.01$, $R^2 = 0.718$).

7.3.5 The effect of "cooked right" beef on each of the degrees of doneness for the traits of taste, tenderness, overall satisfaction, value for money and repurchase intent.

The mean scores and significant differences for taste, tenderness, overall satisfaction, value for money and repurchase intent when the beef is cooked to the consumers ordered degree of doneness are included in table 7.4.

Table 7.4: The mean palatability scores for beef which was "cooked right" for each degree of doneness.

Degree of Doneness	Taste Score	Tenderness Score	Overall Satisfaction Score
Rare	4.8[a]	4.7	4.6
Medium/Rare	4.7[b]	4.7[c]	4.6
Medium	4.6	4.5	4.5
Medium/Well Done	4.5[ab]	4.4[c]	4.4
Well Done	4.6	4.5	4.5

The mean scores with similar superscripts were the only significant differences found a, b and c ($P<0.01$).

There were no differences in overall satisfaction for the various degrees of doneness if the beef was "cooked right". The only significant difference for value for money between the various degrees of doneness was that of Medium/rare and medium/well done ($P<0.01$).

7.3.6 Beef delivered to a specific degree of doneness

Given the design there was the opportunity to further analyse the consumers of one food service outlet who ordered roast "rostbiff" rump only. This product was cooked to and assessed as "medium/well done" degree of doneness by qualified chefs.

The assessments of the degree of doneness by consumers of this product are as follows:

Rare	nil
Medium/Rare	8%
Medium	29%
Medium/Well Done	19%
Well Done	42%
Unspecified	1%

Comparing the consumer assessed and preferred degree of doneness showed that 63% of the beef delivered were to the consumer's preferred degree of doneness. Although only 19% assessed the product as medium/well done, overall 63% assessed the product as matching their preferred degree of doneness.

7.4 DISCUSSION

The ability of consumers to receive beef to the right degree of doneness ordered has a very significant affect on their perception of taste, tenderness, overall satisfaction, value for money and repurchase intent.

Macdougall, (1994) describes how humans conceptually misunderstand colour as a property of the light or the illuminated object, whereas it is actually a sensation of the mind. This sensation of the mind may identify the linkages both positive and negative that the variation in degree of doneness has on perceived palatability traits and value/repurchase assumptions.

In an attempt to rectify the red myoglobin affect on the mind, the use of blue coloured glasses could be used as blue diffuses the red myoglobin pigment colour and this may be used in sensory panels to eliminate the effect degree of doneness has

on sensory scores. Further research needs to be carried out on the use of blue lighting on consumers sensory perceptions. Food service outlets should also develop colour photos of various degrees of doneness and include these with the menu.

While tenderness is often considered by consumers as the most important factor determining meat quality (Chrystall, 1994), these results demonstrate that if the beef is cooked to the consumers ordered perceived degree of doneness, only 4.7% score the beef very poor or poor for tenderness. However, if the beef is not delivered to the ordered degree of doneness, these percentages rise to 11.7% and 22.9% for "undercooked" and "overcooked" respectively.

If the beef was "cooked right" the only significant result for tenderness, was between those that ordered their beef medium/rare compared to those ordering medium/well done. These results show no other significance between the other combinations of degrees of doneness, even between those that order rare compared to well done consumers. This suggests consumers who order their beef at higher degrees of doneness are more tolerant of tenderness, than those that order their beef rare.

These results are in line with Dransfield,(1982) where despite end-point temperatures varying from 60-75 degrees Celsius across European countries the ranking of tenderness was similar at the different research centres.

There was no significant difference between the various degrees of doneness in overall satisfaction score if the beef was "cooked right" (Cox, 1995).

If the beef was "cooked right', consumers only assessed 2.2% of the product very poor or poor for taste. These results indicate that if the beef is "cooked right" the taste of the product is acceptable.

These results may indicate why there is variation between objective tenderness, sensory panellist scores and the perception of tenderness by the consumer. If the beef is "cooked right" consumers may only be able to pick up the least tender product. Because consumers lower their sensory scores for tenderness, taste and overall satisfaction if the beef is not cooked to the ordered degree of doneness, these results indicate that these palatability traits are less reliable for consumers to assess if the survey or sensory tests are not adjusted for the individual consumers ordered degree of doneness.

The relationship between end-point internal temperatures and cooked colour has been well accepted for beef steaks, (Cornforth, 1994). However, the temperatures used to describe the various degrees of doneness are variable, table 7.5.

Table 7.5: Reported relationships between end-point internal temperatures and degree of doneness.

Author	Rare	Medium/ Rare	Medium	Medium/ Well Done	Well Done
			(degrees Celsius)		
U.S. Meat Board,1978	60	65	70		75
Dodgshun, G.,1995	60		70		76
Forrest, J.C.et al 1975	58-60	66-68	73-75		80-82
Cornforth,1994	60			71	82
Laurie,1991	60		60-70		70-80
Kinton,R.,1992	60		70		80

Because of this large variability, some chef training institutions use a method of comparing the pressure exerted on top of the beef steak with that of the skin, muscle and bone of the palm and thumb of the hand, (Morrison, F. pers. com.,1995).

The effect of pH slowing down myoglobin denaturation at the

same internal temperature (Trout, 1989; Cox et.al., 1994) needs to be further investigated to assess the effect on palatability traits.

At one site consumers were only surveyed when roast beef was ordered. Although the roast beef was only cooked to medium/well done (chefs' assessment) 63% of consumers still said they received beef cooked to their desired degree of doneness. This percentage is higher than expected as the total consumers surveyed at all sites only received 69% of their beef "cooked right" for degree of doneness. Another site was able to deliver 86% of consumers ordered degree of doneness, if this was attained over the whole survey sample, this would still lead to 529 consumers not receiving their ordered degree of doneness.

Both value for money and repurchase intent were significantly affected by whether the delivered matched the ordered degree of doneness.

These two factors are considered a high priority in maintaining customer loyalty and increasing patronage.

Consumers scores for taste, tenderness and overall satisfaction were highly correlated. This high correlation may indicate that consumers aren't able to discriminate the finer differences of taste and tenderness. The low percentages of very poor and poor ratings when the beef was "cooked right" may be further evidence of this fact.

7.5 CONCLUSION

Food service outlets should develop colour photos of various degrees of doneness and include these with the menu. These degree of doneness photos should not mention the words rare, medium/rare, medium, medium/well done or well done as these words have various connotations to each consumer, instead a 1 to 5 or 1 to 6 label should relate to each degree of doneness photo. This concept should be trialed to validate if consumers ordered and perceived delivered degree of doneness can be improved.

Because of the high variation of degree of doneness at the same temperature caused by the pH of beef (Trout, 1989; Cox et al., 1994),a tight pH range should be included on the beef purchasing specifications and defined internal temperature guidelines given for each degree of doneness photo.

Chefs should understand the consequences of not delivering the ordered degree of doneness of beef and the relationship perceived consumer degree of doneness has when compared to the science of meat tenderness and taste.

Further research needs to be carried out on the effect different coloured lighting has on consumers sensory perceptions.

Chapter 8: GENERAL DISCUSSION AND CONCLUSIONS

8.1 INTRODUCTION

At the start of this study in June 992, the Australian food service industry was facing a major dilemma of how to overcome the number of customer complaints from beef meals. Many companies were unable to comprehend that beef was a very variable product and that this variation was not always visible when purchasing beef. This was vastly different to many other raw commodities used in the food service industry.

Beef at this time was purchased on the assumption that your supplier knew what you required and through this knowledge was able to procure beef that met your requirements. This purchasing procedure put a lot of faith in the beef supplier, it also enabled the supplier to substitute less acceptable product at various times enabling a lower price to be maintained or higher profit margins for suppliers. This visual expression of wealth by many beef suppliers was noticed by a number of the larger companies and thus tendering procedures and basic specifications were implemented to try to attain consistent beef at a lower price.

However, many of these specifications were written in terms that had various meanings between different value chain segments eg. chefs perceive that export quality beef was the highest quality, but beef suppliers knew that Australia exports beef from the highest to the lowest quality. These loopholes were exploited when suppliers would put forward high quality beef for tendering and then after a short period of time reverted to a low quality and cheaper product that would increase customer complaints.

Best practice enabled food service companies to form better relationships with their suppliers. These relationships brought the suppliers closer to the food service companies'

consumers and demonstrated the variation in eating quality and nature of consumer complaints received. The development of a team approach to solve many of these issues gave very significant and quick improvements to the consistency and quality of beef supplied and inturn a reduction in complaint levels.

The team approach combining food service companies and their suppliers enabled specifications to be written that accurately delivered what the consumer required, formed trained taste panels that monitored the eating quality of random beef samples from commercial production and developed a more efficient purchasing procedure. Beef suppliers were continually updated with results of customer surveys and random monthly sensory results.

Suppliers now have a better knowledge of their beef products and are able to use this knowledge for competitive advantage over other suppliers when servicing a variety of food service companies. The use of the beef audit results gives beef suppliers involved the knowledge of which processing companies supply the highest percentage of beef in specification and by combining this information with the price at any given time they are able to compare the most cost effective product to source that meets the customers' requirements.

It is of interest to note that all the companies that initiated best practice programs are still involved in continuous improvement processes, this is encouraging as some sectors of the market chain have pursued actions and limited supply processes to try to stop these procedures from being implemented. These actions were further pursued by processing companies through industry bodies. In particular, the use of pH as a food service specification criteria was vigorously fought. However, it is worthy to note that the industry body that was against the use of pH now includes pH in all their food service industry beef specifications recommendations.

The continuum of research from the initial identification of consumer complaints from Q.F.C.L., to how variations of delivered degree of doneness were achieved given near

identical preparation and cooking procedures, auditing the variation in some objective and subjective quality traits of beef sourced for the Australian food service industry and the relationship between consumers perceived degree of doneness and palatability traits and the commercially important criteria of value for money and repurchase intent, has enabled the best practice procedures developed in chapter 3 to be tested over a wide range of food service companies and enterprises in a variety of demographic circumstances.

8.2 SYNTHESIS

Commercial research requires delivered outcomes that improve customer satisfaction and improve net profit by improving patronage, lowering cost, improving price margins or gains in general efficiency.

Over the two year monitoring period of the Q.F.C.L. meat enhancement program customer complaints were lowered by 96 percent and sensory scores of beef improved by 36%, 24% and 34% respectively for tenderness, taste and overall satisfaction.

Variation of supplier product lines were reduced at each catering centre, while improved efficiency and wastage rates were achieved with the development of new improved cuts of beef and lamb. In a number of cases these developments were carried out at the suppliers premises, thus creating further efficiency as any trimmings or portions not used could be utilised by a wider variety of clients.

Over this period the meat colour became lighter, pH decreased but there was a small but not significant increase in cooking loss. Fresh beef tenderloins had improved tenderness, taste and overall satisfaction sensory scores than frozen beef. However, if the beef had been frozen the higher pH beef had improved overall satisfaction scores than the low pH beef. While the pH level of both fresh and frozen beef was not significantly different the cooking loss of the frozen beef was significantly higher.

There was a large variation between suppliers for tenderness, taste, overall satisfaction sensory scores and the pH level of the beef supplied. Over the first year of monitoring there was 18.5% of beef assessed with pH over 5.7 pH and 3.4% above 5.9 pH. The relationship between pH and meat colour was highly significant ($P<0.01$ $R^2 = 0.286$). The pH was the only objective assessment that affected the overall satisfaction of beef and the tenderness, taste and overall satisfaction of lamb. The results for lamb reported the pH relationship with tenderness was linear but for beef it was curvilinear, these results for beef are similar to those of Bouton et al., (1973). However, there was still a large variation in delivered degree of doneness under the part cook/chill/reheat cooking process.

The commercial research reported in chapter 5 on the influence of pH and degree of doneness was prompted by the variation identified at Q.F.C.L.

The relationship between pH and degree of doneness of beef fillet steaks demonstrate that for a 1 unit increase in pH results in a decrease of 1.8 doneness scores, an increase of 10mm in steak thickness resulted in a decrease of 0.5 doneness scores and an increase in 10 degrees Celsius internal temperature resulted in a decrease of 1.3 doneness scores.

The pH also significantly affected the thaw and cooking loss with an increase in 1 pH unit resulting in an 8% and 6% unit decrease in thaw and cooking loss respectively. A 10 degrees Celsius increase in internal temperature resulted in a 4% unit increase in cooking loss.

High pH beef fillet steaks will be less done at the same internal cooked temperature and will require further cooking to attain the desired degree of doneness. This further cooking will increase the protein hardening and loss of juiciness.

The results for the relationship between pH and tenderness indicate a linear relationship similar to those reported by Dransfield (1981). These variations in the relationships may be explained by the effect degree of doneness at the same internal temperature has on tenderness and that the commercial Q.F.C.L. results, reported in chapter 4 include some

beef muscles that may be able to shorten, e.g. Striploin (Eikelboom, 1993).

Because of the significant effect pH has on degree of doneness and some palatability traits, food service companies and their suppliers need to know the variation in pH and other objective and subjective important traits of beef that are sourced for their industry. The beef audit program assessed product from all over Australia with the exception of the Northern Territory.

There was a large variation of pH, meat colour, marbling percent and texture and firmness of beef tenderloins assessed. With 41% of beef tenderloins failing to meet a common food service industry specification, this variation was significant between Aus-meat cipher categories and processing suppliers. The variation between Aus-meat cipher categories ranged from 83% for Prime category down to only 43% for "A" category. The range between processor suppliers varied from 100% for one processor down to 0% for four processors.

Of the beef tenderloins assessed 7.2% were above the industry standard of 5.7 pH, 9.5% were above the Aus-meat meat colour score 1A to 3 (industry standard) and 10% were coarser and softer than industry requirements for texture and firmness.

There was no significant difference in pH of grassfed or grainfed beef tenderloins, with a mean pH of 5.64, maximum of 6.61 and minimum of 5.38. Nevertheless, there were still 43% of the grassfed and 33% of the grainfed tenderloins failing to meet the industry specifications. The grainfed tenderloins were significantly lighter in colour than the grassfed tenderloins. The only significant difference between Aus-meat cipher categories and pH reported was that the "A" category was significantly higher than other categories.

There was a significant difference in marbling percentage between beef tenderloins sourced from the various processors and between the older Aus-meat cipher categories of "A", Prime and "S", having higher marbling percentages than the younger categories of "Y" and "YG". Only 4.2% of beef tenderloins assessed had a marbling percentage above 2.8% or

above an Aus-meat marbling score of 2.

The amount of variation of beef tenderloins being sourced for supply to the food service companies indicated that without objective equipment and the development of subjective skills, suppliers were unable to accurately supply beef to the specification requirements. Best practice has delivered training on these issues and by the combination of food service quality assurance personnel and beef suppliers receiving the same training, both segments of the value chain have a better understanding and commercial approach to delivering beef that is of the correct quality for the food service industry.

While the literature review showed the various impact pH has on palatability traits there was no evidence of how the consumers perception of degree of doneness affected their sensory assessments. A group of four companies with ten food service outlets were surveyed at the actual time random commercial consumers eat the beef meals. These results of 3,780 consumers highlighted that only 69% of consumers received their meal to their ordered perceived degree of doneness, 17% were perceived undercooked and 14% perceived overcooked.

There was a significant difference between whether the consumer received their beef to the perceived degree of doneness ordered and the consumers assessment of tenderness, taste, overall satisfaction, value for money and repurchase intent. The repurchase intent was significantly affected by the consumers assessment of taste, tenderness, overall satisfaction and value for money. The percentage of consumers ordering well done beef increased as consumers attitude to eating beef lessened.

If the beef was delivered to the consumers perceived ordered degree of doneness, there was no significant difference between the degrees of doneness and overall satisfaction of beef and the only significant difference between the various degrees of doneness and tenderness was between medium/rare and medium/well done. These results may indicate that consumers who order their beef at the higher degrees of doneness are more tolerant of tenderness than those that eat their beef at a lower degree of doneness.

Consumers perceptions of degree of doneness affect their assessments of palatability traits therefore it is important that food service companies develop colour photos of the various degrees of doneness for beef and include these with the menu. Because humans conceptually misunderstand colour as a property of the light or the illuminated object and not as a sensation of the mind, the linkage (both positive and negative) between the various degrees of doneness and past experiences, it is important that these colour photos not be associated with negative experiences, therefore, new terminology with positive connotations should be developed. This concept should be trialed under commercial conditions in various demographic locations to fine tune the concept and develop marketing advantage.

The tenderness, taste and overall satisfaction scores of consumers are very highly correlated, this may indicate that consumers are not able to discriminate the finer differences of taste and tenderness. These results may explain why some research papers report low relationships between objective tenderness assessments, trained taste panel results and commercial consumer findings.

These results obtained across a wide variety of food service outlets warrant the education of chefs to develop an understanding of the relationship consumer's perceived degree of doneness has on meat palatability traits and the comparison of these results with the science of meat tenderness and taste.

Because of the effect pH has on palatability traits, degree of doneness and the effect consumers perceived degree of doneness has on consumers assessment of tenderness, taste, overall satisfaction, value for money and repurchase intent all food service specification should stipulate a pH range of 5.4 to 5.7. This narrow pH range will deliver consistent degree of doneness and improved palatability of fresh beef products given all other constraints are equal eg. evenness of cooking due to type of equipment.

While the majority of conclusions reported here are of a scientific or technical basis, the actual credit for many of the changes were brought about by the leadership of these companies and their commitment to change for future customers requirements, to identify

and give responsibility to people who could make the change, to implement a management structure and process of best practice, to develop training in technical and skills areas that delivered accurate specifications and quality assurance programs while working with key suppliers who believed and committed their businesses to supply beef that met or exceeded consumers satisfaction requirements.

The best practice procedures for food service leading firms outlined in chapter 3 demonstrates a model that is flexible for various segments of the industry and can be customised to individual company requirements.

The combination of best practice and the adoption of appropriate meat palatability research has, I believe, brought together a process that can deliver improved consumer satisfaction and profitability to all members of the food service value chain.

7.3 FURTHER RESEARCH

The effect the mind has on humans' perceptions of colour needs further investigation, especially to understand the eating behaviour and assessment of various palatability traits. This research needs to include the effect coloured lighting has on human perceptions and the effect coloured glasses may have on trained and untrained sensory panels.

An audit of the various cooking equipment and efficiency of cooking red meats needs to be carried out, identification of temperature delivery, cooking times, cooking specifications and an accurate measure of degree of doneness (as this relates to the consumers perception) also needs further investigation.

Commercial devices need to be developed that can accurately assess degree of doneness without opening or cutting the beef, these devices need to be practical and easy to use.

Further research and education needs to be implemented with meat processors, feedlotters

and beef producers on the implications of not meeting consumers' satisfaction requirements and the impact this will have over the medium to long term periods.

BIBLIOGRAPHY

Anon. (1994a) Leading the way, second edition. A study of best manufacturing practices in Australia and New Zealand. Final report of the study by the Australian Manufactures Council.

Anon. (1994b) The wealth of ideas. How linkages help sustain innovation and growth. Report by the Australian Manufacturing Council Secretariat and McKinsey and company to Australian Manufacturing Council.

Anon. (1994c) Emerging exporters. Australia's high value-added manufacturing exporters. Final report of the study by McKinsey and company and the Australian Manufacturing Council Secretariat to the Australian Manufacturing Council.

Anon. (1994d) Achieving best practice management. Australian Quality Council Ltd. 69 Christie Street, St Leonards, N.S.W. Australia.

Anon. (1994e) Benchmarking self help manual. Australian Government Publishing Service, GPO Box 84, Canberra, ACT. Australia.

Anon. (1994f) Full report: National beef tenderness conference, National Cattlemans Association. Denver, Colorado, United States of America.

Anon. (1994g) The International Markets for Meat General Agreement on Tariffs and Trade, Fourteenth Annual Report.

Anon. (1994h) Assessment Criterial published by Australian Quality Awards Foundation Ltd, PO Box 298, St Leonards, N.S.W.

Boleman, S.J., Boleman, S.L., Bidner, T.D., McMillan, K.W. and Monlezun, C.J. (1995) Effects of post mortem time of calcium chloride injection on beef tenderness and drip, cooking and total loss. Meat Science 39, 35-41.

Boucek, R.J., Noble, N.L. and Marks, A. (1961) J. Gerontol. 5, 150.

Bouton, P.E., Howard, A., and Lawrie, R.A. (1957). Studies on Beef Quality. Part VI. H.M.S.O. London. 23pp.

Bouton, P.E., Howard, A., and Lawrie, R.A. (1958). Studies on Beef Quality. Part VII. H.M.S.O. London. No. 67.

Bouton, P.E., Carroll, F.D., Fisher, A.L., Harris, P.V., and Shorthose, W.R. (1973) Effect of altering ultimate pH on bovine tenderness. J.Food Sci. 38, 816.

Bouton, P.E., Ford, A.L., Harris, P.V. and Redcliffe, D. (1975) Objective-subjective assessment of meat tenderness. J. Text. Stud. 6, 315

Bouton, P.E.., Ford, A.L., Harris, P.V., Shorthose, W.R., Ratcliff, D. and Morgan, J.H.L., (1978) Influence of animal age on the tenderness of beef: muscle differences. Meat Science 2, 301-311.

Bowers, J.A., Craig, J.A., Kropf, D.H and Tucker, T.J. (1987) Flavor, colour, and other characteristics of beef longissimus muscle heated to seven internal temperatures between 55 degrees C. and 85 degrees C. J. Food Science 52, 533.

Bramblett, V.D. and Vail, G.E. (1964) Further studies on the qualities of beef as affected by cooking at very low temperatures for long periods. Food Tech. 18, 245.

Bryce-Jones, K., Houston, T.W. and Harris, J.M. (1963) J. Science, Food and Agriculture 14, 637

Carpenter, J.W., Palmer, A.K., Kirk, W.G., Peacock, F.M. and Koger, M. (1955) J. Animal Science 14, 1228.

Carr, D.K., and Johansson, H.J., (1995) Best practices in reengineering. McGraw-Hill, Inc. 11 West 19th Street, New York, N.Y. 10022.

Cartwright, T.C., Butler, O.D. and Cover, S. (1958) Proc. 10th Research Conf. American Meat Inst. Foundation, 75.

Casey, D.P., (1995) Best practice management processes. Open learning unit, Regency Institute of TAFE, Port Adelaide Campus, South Australia, Australia.

Caul, J.F. (1957) The profile method of flavor analysis. Adv. Food Research 7, 1.

Chrystall, B. (1994) Meat Texture Measurement in Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Cornforth, D. (1994) Colour - Its Basis and Importance in Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Cover, S., Ritchey, S.J. and Hostetler, R.L. (1962) Tenderness of beef. II. Juiciness and the softness components of tenderness. J. Food Science 27, 476.

Cox, R.J., Thompson, J.M., Elwin, P., Predeth, M. and Casey, D.P. (1994) Influence of pH on myoglobin denaturation (degree of doneness) in set cooked beef fillet steaks. 40th International Congress on Meat Science and Technology. The Hague.

Cox, R.J., (1994) Meat palatability resource book. Open learning unit, Regency Institute of TAFE, Port Adelaide Campus, South Australia, Australia.

Cox, R.J., Elwin, P., Predeth, M., Cunial, C.M. and Thompson, J.M. (1995) Final report. Q.F.C.L. meat enhancement program. Meat Research Corporation. Australia.

Cross, H.R. and Savell, J.W. (1994), What do we need for a value-based beef marketing system?, Meat Science 36, p 19-27.

Dayton, W.R., Goll, D.E., Stromer, M.H., Reville, J., Zeece, M.G. and Robertson, R.M. (1975) Some properties of a Ca 2+ activated protease that may be involved in myofibrillar protein turnover. In: Proteases and biological control. Publ. Cold Spring Harbour Laboratory, p. 551.

Davey, C.L. and Gilbert, K.V. (1974) Temperature-dependent cooking toughness in beef. J. Science Food Agriculture 25, 931.

Dayton, W.R., Goll, D.E., Zeece, M.G., Robson, R.M. and Reville, W.J. (1976) A Ca 2+ activated protease possibly involved in myofibrillar protein turnover. Purification from porcine muscle. Biochem. 15, 2150.

Dertouzos, M.L., Lester, R.K. and Solow, R.M. (1989) Made in America: Regaining the competitive edge. MIT Press.

Dodgshun, D. (1995) Degree of Doneness in Cookery for the Hosptiality Industry. Published by Hodder Education, 10-16 South St, Rydalmere, N.S.W.

Dransfield, E., (1981). Eating quality of DFD beef. In 'The Problem of Dark-cutting in Beef'. (Ed. D.E. Hood, and P.V. Tarrant), .Marinus Nijhoff. The Hague. p.344.

Dransfield, E., Rhodes, D.N., Nute, G.R., Roberts, T.A., Boccard, R., Touraille, C., Butcher, L., Hood, D.E., Joseph, R.L., Schon, I., Castells, M., Cosentino, E. and Tinbergen, B.J. (1982) Eating quality of European beef assessed at five research institutes. Meat Sci.6,163.

Dransfield, E., (1985) Evidence of consumer reaction to meat of different origins, in The Long-term Definition of Meat Quality: Controlling the variability of quality in beef, veal, pigmeat and lamb (ed. G. Harrington), Commission for the European Communities, Brussels, 45.

Dransfield, E., (1992b) Modelling post mortem tenderisation 1. Texture of electrically stimulated and non stimulated beef. Meat Science 31, 57.

Dransfield, E., (1994) Tenderness Of Meat, Poultry and Fish in Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Eikelenboom G. (1993). Effect of various processing methods on the meat quality of beef and pork. Proc 39th ICMST Calgary, Alberta, Canada.

Gacula, M., Jr. (1987) Some issues in the design and analysis of sensory data: Revisited. J. Sensory Studies 2, 169.

Goll, D.E., Taylor, R.G., Christiansen, J.A. and Thompson, V.F. (1991) Role of proteinases and protein turnover in muscle growth and meat quality Proc. Recip. Meat Conf. 41, 25.

Gordon, A.J., Alder, H. and Cabassi, P. (1994), Chiller Assessment - Video Image Analysis for Japan, 28th Meat Research Conference.

Gorny, R.A. and Ahmadi-Esfahan, F.Z. (1993), Structural Change in the Demand for Differentiated Meat Products in Sydney. Review Marketing and Agricultural Economics, Vol 61, No 1, p 63-71.

Gray, J.I., Pearson, A.M. and Monahan, F.J. (1994) Flavor and aroma problems and their measurement in meat, poultry and fish products. In: Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Griffin, C.L., Stiffler, D.M., Ray, E.E. and Berry, B.W. (1981) Effects of electrical stimulation, boning time and cooking method on beef roasts. J. Food Science 46, 987.

Hammer, M. and Champy, J (1994) Reeingineering the corporation: a manifesto for business revolution. Allen and Unwin, 9 Atchison Street, St Leonards, N.S.W. Australia.

Hammond, J., (1932) Growth and development of mutton qualities in the sheep. J. Royal Agric. Soc. 93. 131.

Harrington, G. (1994), Consumer Demands: Major Problems Facing Industry in a Consumer-Driven Society, Meat Science, 36, p 5-18.

Harris, J.M. and MacFie, H.J.H. (1976) The use of rotational fitting technique in the interpretation of sensory scores for different characteristics. J. Food Technology 11: 449.

Hornstein, I. and Wasserman, A. (1987) Part II. Chemistry of meat flavor. In: The science of meat and meat products (eds. J.F. Price and B.S. Schweigert), Food and Nutrition Press, Westport, Connecticut, p 329-347.

Howard, A. and Lawrie, R.A. (1956) Studies on beef quality, parts V. Spec. Rept. Food Invest. Bd. London. No 65.

Ingram, M. (1948) Ann. Inst. Pasteur, Lille 75, 139.

Jones, S.D.M., Jeremiah, L.E., Tong, A.K.W., Lutz, S. and Robertson, W.M. (1991) The effects of marbling level, electrical stimulation and post mortem ageing on the cooking and palatability properties of beef rib eye steaks. Can. J. Animal Science 71, 1037-1043.

Kidwell, J.F. (1952) J. Hered. 43, 157.

Kingston, O.L., Congram, I.D., Hopkins, A.F., Harris, P.V., Powell, V.H., Shorthose, W.R. and Swain, A.J. (1988) Australian consumer requirements for beef and lamb. Part 3. Consumer preferences for selected beef classification criteria. Research series report No 22. Livestock and Meat Authority of Queensland.

Kinton, R., Ceserani, V. and Foskett, D. (1992) The theory of catering. Hodder and Stoughton Press, Mill Rd, Dunton Green, Kent, England.

Koch, R.M., Crouse, M.E., Dikeman, M.E., Cundiff, L.V. and Gregory, K.E. (1988) Effects of marbling on sensory panel tenderness in Bos Indicus and Bos Taurus crosses. J. Animal Science 66, 305 (abstr.).

Koohmaraie, M., (1994) Muscle proteinases and meat aging. Meat Science 36. 93-104.

Koohmaraie, M., (1995) The calpain system. Meat '95. The Australian meat industry conference. Gold Coast. Australia.

Kurth, L., (1993) Collagen - the tough truth about meat. Meat '93 The Australian meat industry conference. Gold Coast. Australia.

Lawrie, R.A. (1958) Physiological stress in relation to dark-cutting beef. J. Science Food Agric. 14, 787.

Lawrie, R.A., (1991) Meat science. Fifth edition. Pergamon Press plc. Oxford OX3 OBW, England.

Lewis, G.J., Puslow, P.P. and Rice, A.E. (1991) Meat Science 30, 1.

Light, N.D. and Bailey, A.J. (1983) Proc. 29th. European Meeting Meat Res. Workers, Salsomaggiore. p 135.

Lochner, J.V., Kauffman, R.G. and Marsh, B.B. (1980) Early post mortem cooling and beef tenderness. Meat Science 4, 237.

Love, J. (1994) Product Acceptability Evaluation. In: Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Loxton, I.D., Shorthose, W.R., Holroyd, R.G., Rogers, S.A., Blight, G.W., Neill, A.R., James, T.J., Jeffery, M.R. and Fordyce, G. (1993) The influence of animal nutrition on the quality of meat from Bos Indicus cross-bred steers in northern Australia. Meat '93 The Australian meat industry conference. Gold Coast. Australia.

Lubbe, W.F. (1991), Normalising Competition in Agricultural Marketing - The Case for Red Meat in South Africa, Agrekon, Vol 30, No 4.

Luckett, R.L., Bidner, T.D., Icaza, E.A. and Turner J.W., (1975) Tenderness studies in straightbred and crossbred steers. J. Animal Science 40, 468.

Lyon, B.G., Greene, B.E. and Davis, C.E. (1986) Colour, doneness and soluble protein characteristics of dry roasted beef semitendinosus. J. Food Science, vol 51, 1,24.

Macdougall, D.B.(1994) Colour Of Meat in Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Marsh, B.B. (1993). Approaches to manipulate postmortem metabolism and meat quality. Proc 39th ICMST Calgary, Alberta, Canada.

McBride, R.L. and Finlay, D.C. (1989) Perceptions of taste mixtures by experienced and novice assessors. J. Sensory Studies 3, 237.

McCormick, R.J., (1994) The flexibility of the collagen component of muscle. Meat Science 36, 79-91.

Mitchell, G.E., Rogers, S.A., Ferguson, D.M., Giles, J.E., Tan, L.T. and Naidoo, R.J. (1988) A study of the combined effects of common industrial and household beef handling practices on the attributes of beef palatability to the consumer. Research report 24. Livestock and Meat Authority of Queensland.

Morgan, J.B., Savell, J.W., Hale, D.S., Miller, R.K., Griffin, D.B., Cross, H.R. and Shakelford, S.D. (1991) National Beef Tenderness Survey. J. Anim. Sci. 69, 3274.

Morgan, J.B., (1992) Tenderness problems and potential solutions. In: The final report of the National Beef Quality Audit. 180-187.

Morrison, F. (1995) Chefs course material, TAFE, Orange.

Nishimura, T., Hattori, A. and Takahashi, K. (1995) Structural weakening of connective tissue during conditioning of beef. Meat Science 39, 127-135.

Olsson, U., Hertzman, C. and Tornberg, E. (1994) The influence of low temperature, type of muscle and electrical stimulation on the course of rigor mortis, ageing and tenderness of beef muscles. Meat Science 3", 115-131.

Oreshkin, E.F. and Borisova, M.A. (1988) Structural changes in beef muscle proteins during heating. Proc 36th ICMST Brisbane, Australia.

Ouali, A. and Talmant, A. (1990) Calpains and calpastatin distribution in bovine, porcine and ovine skeletal muscles. Meat Science 28, 331.

Palmer, A.Z., (1963) Tenderness testing device. Canadian Patent 639364. Proc. Meat Tenderness Symp., 161. Campbell Soup Co. Camden, N.J.

Penny, I.F., Voyle, C.A. and Lawrie, R.A. (1963) J. Science Food Agric. 14, 535

Richardson, N.J., MacFie, H.J.H and Shepherd, R. (1994), Consumer Attitudes to Meat Eating, Meat Science 36, p 57-65.

Romans, J.R., Tuma, H.J. and Tucker, W.L. (1965) Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. 1 Palatability, fibre diameter and proximate analysis. J. Animal Science 24.

Savell, J.W. and Shackelford, S.D., (1992) Significance of tenderness to the meat industry. Proc. Recip. Meat Conf. 45, 43-50.

Shackelford, S.D., Koohmaraie, M., Cundiff, L.V., Gregory, K., Rohrer, G.A. and Savell, J.W. (1993) Heritabilities and phenotypic and genetic correlations for bovine postrigor calpastatin activity, intramuscular fat content, Warner-Bratzler shear force, retail product yield and growth rate. J. Animal Science (submitted).

Shorthose, W.R., (1993) How important are breed differences? Meat '93 The Australian meat industry conference. Gold Coast. Australia.

Shorthose, W.R. and Harris, P.V., (1990) Effect of animal age on the tenderness of selected muscles. J. Food Science Vol. 55, No 1, 1-14.

Teys, A., (1993) An Australian industry perspective of the present and the future. Meat '93 The Australian meat industry conference. Gold Coast. Australia.

Trout, G.R. (1989). Variation in myoglobin denaturation and colour of cooked beef, pork and turkey meat as influenced by pH, sodium chloride, sodium tripolyphosphate, and cooking temperature. J Food Sci. 54, 536.

Tuma, H.L., Hendrickson, R.L., Stephens, D.F. and Moore, R., (1962) Influence of marbling and animal age on factors associated with beef quality. J. Animal science 21, 848.

van Ginkel, J.A. (1993) Post mortem muscle proteolysis and beef tenderness. A study for the Netherlands Commodity Board for Livestock and Meat.

Warner, R.D. (1988). Objective description of meat and fat colour in beef carcasses. In "The automated measurement of beef" (Ed. L.E. Brownlie, W.J.A. Hall, and S.U. Fabiansson). The Australian Meat and Livestock Corporation, Sydney.

Wasserman, A.E. and Spinelli, A.M. (1972) Effect of some water-soluble components on aroma of heated adipose tissue. J. Agric. Food Chem. 20, 171.

Wheeler, T.L., Cundiff, L.V. and Koch, R.M. (1993a) Effect of marbling degree on palatability, meat yield and caloric content of beef. J. Animal Science

Whipple, G., Koohmaraie, M., Dikeman, M.E., Crouse, J.D., Hunt, M.C. and Klemm, R.D. (1990) Evaluation of attributes that affect longissimus muscle tenderness in Bos taurus and Bos indicus cattle. J. Animal Science 68, 2716.

Winger, R.J. and Hagyard, C.J. (1994) Juiciness - its importance and some contributing factors. In: Quality Attributes And Their Measurement In Meat, Poultry And Fish Products (ed. A.M.Pearson and T.R.Dutson) Advances In Meat Science Series, Volume 9 Pub. by Blackie Academic and Professional.

Womack, J.P., Jones, D.T. and Roos, D. (1990) The machine that changed the world. Rawson Associates, Macmillan Publishing company, 866 Third Avenue, New York. N.Y.10022