MEAT RESEARCH CORPORATION

FINAL REPORT

PROJECT DAQ 52 - Effect of postweaning nutrition on carcase yield and meat quality

Queensland Department of Primary Industries (QDPI)

CSIRO, Meat Research Laboratory, Cannon Hill, Queensland

Queensland
Department
of Primary
Industries

CSIRO
AUSTRALIA

ABSTRACT

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CSIRO, Meat Research Laboratory, Cannon Hill, Queensland

Principal Researchers:	Mr I. Loxton, QDPI, Rockhampton (Project Leader)
	Dr R. Shorthose, CSIRO, Cannon Hill
	Dr A. Neill, QDPI, Brisbane
	Mrs S. Rogers, QDPI, Brisbane
	Mr G. Blight, QDPI, Yeerongpilly (Biometrician)
Project Supervisor:	Dr R. Holroyd, QDPI, Kingaroy (Supervisor)

Project Title: Effect of postweaning nutrition on carcase yield and meat quality.

Project No.: DAQ 52

Research Organisations and Location:

Queensland Department of Primary Industries
- Rockhampton
- Brigalow Research Station, Theodore
- Animal Research Institute, Yeerongpilly
- International Food Institute of Queensland, Hamilton

CSIRO, Meat Research Laboratory, Cannon Hill

Commencement: July 1986

Completion: June 1991

Project Investigators:

- Mr I. Loxton, QDPI, Rockhampton (Project Leader)
- Dr R. Shorthose, CSIRO, Cannon Hill
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Objective:

To determine whether the postweaning plane of nutrition influences carcase yield and meat quality over a range of slaughter weights.

Summary:

The overall quality (tenderness, juiciness and flavour) of loin steaks (*Longissimus dorsi*) from northern Australian *Bos indicus* cross steers, over a range of ages, carcase weights and from different nutritional histories was considered average. There were no apparent quality differences in steaks from ***grassfed*** or ***grainfed*** steers.

Postweaning nutritional regime had no effect on loin steak juiciness or tenderness at any of the observed target carcase weights, while beef flavour was enhanced at heavier carcase weights.

The influence of pre-slaughter stress and the processing factors - electrical stimulation and carcase chilling regime were of greater importance than nutritional regime *per se* in affecting meat tenderness. These influences may override the effect of nutrition resulting in a lack of the expected relationship between younger turnoff and improved tenderness. Meat colour was influenced by an interaction between age at slaughter (affected by plane of nutrition) and carcase weight.

There was no difference at any of the target carcase weights in any of the indices of carcase fatness (subcutaneous fat cover, marbling score or total fat content of the loin steak) due to the postweaning nutritional regime. For these indices of carcase fatness, loin steaks from ***grassfed*** or ***grainfed*** steers were no different. Marbling score or total fat content of the loin steaks, had no influence on tenderness but had partial influence on beef flavour. Total fat content of the loin steaks was low, for example, an average fat content of 4.19% was the maximum recorded at Japanese market turnoff carcase weights (320 kg).

These are the major results from a large experiment carried out in Central Queensland where 680 *Bos indicus* cross weaner steers were exposed to four different nutritional regimes until turnoff at one of three target carcase weights of 185, 260 and 320 kg. At slaughter, carcase measurements were taken and samples of loin steaks collected for laboratory analysis of meat colour, tenderness, fat content, marbling and sensory evaluation of juiciness, flavour and tenderness.

EXECUTIVE SUMMARY

MEAT RESEARCH CORPORATION
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(i) BACKGROUND AND INDUSTRY SITUATION

About one half of the Australian beef herd (11.3 M head) is located in northern Australia and 80% have a *Bos indicus* content. The turnoff of about 1.6 M male (castrates) and 1.1 M female cattle is either finished in the north or moved to southern regions for growing and finishing. In northern regions, these cattle experience annual nutritional stress and the associated periods of low or negative growth rates. There is, however, little information to define whether these nutritional stresses have any effect on subsequent carcase weight, yield of saleable meat and meat quality. Nutritional stress is not, however, confined to northern regions only, and the basic findings are relevant to southern regions. Any negative effects of the nutritional stress amongst the 1.6 M male turnoff would represent an economically significant loss of potential productivity.

It has become increasingly evident that the beef industry must pay more attention to supplying a consistent quality product to the consumer. Also, to contain processing costs, the importance of yield of saleable meat must not be overlooked. The evolution of marketing systems that base payment on product quality will provide the means to quantify the economic importance of carcase yield and meat quality.

(ii) PROJECT OBJECTIVE

To determine whether the postweaning plane of nutrition influences carcase yield and meat quality over a range of slaughter weights.

(iii) METHODOLOGY

At Brigalow Research Station via Theodore, 680 *Bos indicus* cross steers (50 to 75% Brahman content), as weaners, were allocated into nutritional regime by target weight combination groups. The target carcase weights were designed to average 185, 260 and 320 kg. There were two replications (drafts of animals) of each combination group. The nutritional regime comprised combinations of differing annual nutritional levels between weaning and the final target carcase weight. The nutritional regimes were:

Low, Medium, High (LMH);
Medium, Medium, Medium (MMM);
High, High, High (HHH);

where the High (H) growth rate was - 180 kg/year, Medium (M) - 130 kg/year, and Low (L) growth - 80 kg/year. In draft 2 only, a very high growth rate (H^+ nutritional regime) was evaluated for each of these target carcase weights. The H^+ target growth rate was 300 kg/year.

The nutritional regimes were achieved through stocking rate adjustment, provision of legume augmented pastures, protein and/or grain supplementation.

When a treatment group (plane of nutrition x target carcase weight), consisting of 32 steers reached a target carcase weight they were consigned to slaughter. A standard procedure of handling, trucking and slaughter was adopted. All experimental steers were slaughtered at the same meatworks.

At slaughter, carcases were electrically stimulated, dentition was assessed and measurements of hot standard carcase weight, subcutaneous fat depth at the P8 site, carcase length, carcase depth and eye muscle area were made. After chilling of the carcases, samples of the *Longissimus dorsi* muscle, as the 'cube roll', were collected using a standardised procedure. The samples were sent to the CSIRO, Meat Research Laboratory, Cannon Hill and QDPI laboratories at Yeerongpilly and Hamilton. At the appropriate laboratories, determination of dry matter and fat content and marbling score, objective measurement of meat colour, meat tenderness, sensory evaluation of tenderness, flavour and juiciness of the *Longissimus dorsi* samples were made. The yield of saleable meat was predicted.

Data were statistically analysed using the method of least squares analysis of variance. For statistical analysis, the experimental unit comprised the nutritional regime by target carcase weight combination groups. Relationships between attributes were examined using standard linear or quadratic least squares regression techniques based on the experimental unit.

(iv) MAIN RESULTS AND CONCLUSIONS

The overall quality (tenderness, juiciness and flavour) of *Longissimus dorsi* loin steaks from *Bos indicus* cross steers of different postweaning nutritional history was considered average.

There was no difference in *Longissimus dorsi* steak juiciness, beef flavour or tenderness (measured objectively or subjectively) over a wide range of animal ages or carcase weights. The postweaning nutritional regime had no effect on juiciness or tenderness at any of the target carcase weights, while beef flavour was enhanced at heavier carcase weights. Meat colour was influenced by an interaction between age at slaughter (affected by plane of nutrition) and carcase weight.

Tenderness of the majority of *Longissimus dorsi* steaks was affected by cold shortening (93% steaks had shortened muscle sarcomeres), high ultimate pH values (indicating pre-slaughter stress) in some instances, and high Instron compression values due to the connective tissue contribution and an overriding influence of cold shortening. Approximately half of the *Longissimus dorsi* steaks were considered tough due to their connective tissue contribution. The steaks were cold shortened due to less than effective electrical stimulation following slaughter and a severe chilling regime.

Marbling rating had no influence on the meat tenderness of *Longissimus dorsi* steaks, but had partial influence on beef flavour intensity. Total fat content of these steaks had partial influence on meat tenderness and beef flavour intensity.

Pre-slaughter stress (increased ultimate pH values) occurred in a number of turnoff groups, and was associated with combinations of climatic factors, particularly high ambient temperatures, management of animals prior to slaughter and increased holding times at meatworks prior to slaughter.

The growth rates required to achieve a younger turnoff of pasture fed animals at c. 30 months of age, and at preferred carcase weights, are on average greater than those normally experienced in northern Australia. High input costs may be needed in order to attain growth rates of steers off pasture to meet perceived age/carcase weight criteria at turnoff. The 'whole of life' grain feeding to produce steers for the Japanese market by approximately 27 months of age in one of the nutritional regimes was uneconomic in this project.

Increasing carcase weight influenced the carcase attributes of subcutaneous fat cover, dressing percentage and yield of saleable meat. These attributes were unaffected by nutritional regime. The nutritional regime did not influence the nutritional status of the product, that is, dry matter content, protein content, marbling or fat content. however increased carcase weight increases values of all these attributes. The total fat content of the *Longissimus dorsi* steaks was low, regardless of whether the *Bos indicus* cross steers had been ***grassfed*** or ***grainfed***. Average fat content of *Longissimus dorsi* steaks at target carcase weights of 185, 260 and 320 kg were 1.14%, 2.09% and 4.06% respectively.

The major impact on the industry from this project is the lack of influence of postweaning nutrition *per se* on the tenderness of *Longissimus dorsi* muscles of Brahman cross steers. The project has further highlighted the importance of pre-slaughter stress on meat quality to all sectors of the industry and the importance of two processing factors - electrical stimulation and carcase chilling rates to the processing sector. The influence of pre-slaughter stress and the processing factors are of greater importance than nutritional regime *per se* in affecting meat tenderness. These influences may override the effect of nutrition, resulting in a lack of relationship between younger turnoff and improved tenderness. This result impacts heavily on the producer as there is little benefit cost in pursuing a reduction in turnoff age to improve meat quality unless all sectors of the industry can address the associated overriding influences of pre-slaughter stress and processing factors. All sectors of the industry need to be conscious of these issues and work in consultation with each other to address each issue. In addition to the impact on the industry, the low fat content of *Longissimus dorsi* steaks from Brahman cross steers in northern Australia has significant potential impact for health conscious consumers of northern beef.

From 600 *Bos indicus* cross steers observed in the four nutritional groups of this project, high marbling scores (high fat content) were not recorded. Therefore, the pursuit of high scores is apparently not biologically or economically feasible. In addition, there was a lack of relationship between the *Longissimus dorsi* marbling rating/fat content and meat tenderness, measured either objectively or subjectively.

MAIN REPORT

MEAT RESEARCH CORPORATION
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Queensland Department of Primary Industries (QDPI)
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CONTENTS

(i) ACKNOWLEDGMENTS

Without the assistance and collaboration of many people, this large and comprehensive project which extended across the production/processing interface could not have been carried out. The Queensland Department of Primary Industries and the CSIRO are gratefully acknowledged for their support of the project. We wish to thank the Manager and staff of Weddel (formerly CQME), Rockhampton for their support and assistance in the processing of all project animals and to facilitate data and sample collection. W & M Transport, Tingalpa, Queensland, kindly transported all meat samples for the project from Rockhampton to Brisbane.

We gratefully acknowledge the support of the following people, Mr T. James and Mr T. Mullins for technical support; Mr M. Nasser and numerous farm staff, all of QDPI, Brigalow Research Station; Mr L. McNamara, Mr M. Rickard, Mr P. Bridgeman, Mr J. Fletcher, Mr P. Long, Mr J. Guthrie, Mr K. Dunlop, Miss K. Wheeler and Mr T. Ryan all formerly or currently of QDPI, Rockhampton; Mr B. Burns, QDPI, Richmond; Dr P. Harris, Mrs L. Vanderlinde and Mr R. Dickinson of the CSIRO, Meat Research Laboratory, Cannon Hill; Mr I. Bock, Mr P. Van Melzen, QDPI, Animal Research Institute; Miss L. Tan and Mrs J. Bicanic, QDPI, Hamilton; Mrs J. Giles, QDPI, Brisbane; Miss A. Job for typing this report, and all laboratory staff employed by this project to assist in sample analysis.

(ii) BACKGROUND AND INDUSTRY SITUATION

About one half of the Australian beef herd (11.3 M head) is located in northern Australia and 80% have a *Bos indicus* content. The turnoff of about 1.6 M male (castrates) and 1.1 M female cattle is either finished in the north or moved to southern regions for growing and finishing. In northern regions, these cattle experience annual nutritional stress and the associated periods of low or negative growth rates (Winks, 1984). There is, however, little information to define whether these nutritional stresses have any effect on subsequent carcase weight, yield of saleable meat and meat quality. Nutritional stress is not, however, confined to northern regions only, and the basic findings are relevant to southern regions. Any negative effects amongst the 1.6 M male turnoff would represent an economically significant loss of potential productivity.

It has become increasingly evident that the beef industry must pay more attention to supplying a consistent quality product to the consumer. Also, to contain processing costs, the importance of yield of saleable meat must not be overlooked. The evolution of marketing systems that base payment on product quality will provide the means to quantify the economic importance of carcase yield and meat quality.

(iii) PROJECT OBJECTIVE

To determine whether the postweaning plane of nutrition influences carcase yield and meat quality over a range of slaughter weights.

(iv) METHODOLOGY

Refer to Appendix I.

(v) RESULTS AND DISCUSSION

Refer to Appendix I.

(vi) SUCCESS IN ACHIEVING OBJECTIVES

The objective of the project was achieved, in particular:

1. Predicted yield of saleable meat increased with increasing carcase weight, but was unaffected by the postweaning plane of nutrition. Because the direct measurement of carcase yield was not logistically possible, prediction of the yield of saleable meat was carried out.

2. Meat quality (fat content, tenderness, sensory evaluation rating) was largely unaffected by the postweaning plane of nutrition. However, increasing carcase weight influenced some meat quality attributes. At heavier carcase weights, *Longissimus dorsi* steaks had a higher fat content and marbling rating, longer sarcomeres (and were therefore less affected by muscle shortening) a higher flavour rating and a higher overall sensory quality rating.

(vii) DESCRIPTION OF INTELLECTUAL PROPERTY

Not applicable.

(viii) PROGRESS IN COMMERCIALISATION

Commercialisation of the results to date has largely centred on dissemination of commercial aspects of the data, that is, growth rate, pre-slaughter stress and processing factors and their effects on meat quality to beef producers and meatworks processors. Techniques of dissemination have included:

- Field Days addresses - Brigalow Research Station.
- Displays - AUS●MEAT *Grassfed* Competition open days (1988, 1989, 1990) - Brigalow Research Station.
- Meetings - Brigalow Research Station - Industry Consultative Meeting.
- Meat Quality Review - Rockhampton (1990).
- Industry Conference - Forum for Beef - Mackay, Charters Towers, Biloela and Roma (1991).
- Press articles - Numerous - Regional
  - Focus on Beef
  - Beef Improvement News

(ix) IMPACT ON MEAT AND LIVESTOCK INDUSTRY

The major impact of the project was that postweaning nutritional regime had little impact on the meat quality of Brahman cross steers.

The project has identified minimum growth rates of steers necessary to achieve turnoff for specific markets and in particular the magnitude of growth rates required in order to achieve a significant reduction in turnoff age. The magnitude of costs required to significantly reduce turnoff age have been investigated, using a grain feeding regime, in order to meet the perceived future market specifications. The grain feeding nutritional strategy was not found to be cost effective and could not be recommended. This information has immediate impact on beef production systems throughout northern Australia.

An awareness of pre-slaughter stress and its associated effect on meat tenderness has been created from this project. Some of the causative factors of this type of stress have been identified.

Lean *Longissimus dorsi* loin steaks from the *Bos indicus* steers of this project regardless of nutritional history or carcase weight were low in total fat content. This finding has significant impact to all consumers as they can be reassured that lean meat can be consumed without major impact on their daily total fat intakes. This data is of current importance to the Australian consumer and will assume increasing importance to the Japanese consumers as they look towards lowering their dietary fat intake from meat sources in the future.

A result expected to have considerable impact on the production of beef has been the lack of relationship between the *Longissimus dorsi* marbling rating/fat content and the objective measurements (mechanical) or the subjective (sensory) evaluation of meat tenderness. From 600 *Bos indicus* cross steers observed in the four nutritional groups of this project, high marbling scores (high fat content) were not recorded. Therefore, the pursuit of high scores is apparently not biologically or economically feasible.

Two aspects of the project considered to have a significant impact in the future are pre-slaughter stress and processing factors, both of which have a far more marked effect on meat tenderness than nutritional regime *per se* as shown in this project.

Pre-slaughter stress will impact on beef producers, livestock transporters and meatworks processors, or anyone handling animals destined for slaughter for premium markets. Some of the likely aspects to be considered of importance in overcoming pre-slaughter stress are animal handling, stock yard design on properties and at meatworks, livestock transport design and climatic factors to be considered when consigning stock for slaughter.

Processing factors to ensure a consistent quality product are expected to assume an increasing importance. There are two major processing factors associated with poor meat tenderness. These are ineffective electrical stimulation which results in muscle shortening and fast chilling regimes that also result in muscle shortening and subsequent tough meat. In terms of chiller management, there is a need for chilling regimes that ensure maximum product hygiene standards are maintained. Effective chiller management will also avoid muscle shortening to produce a tender meat product in order to maintain Australia's competitiveness on the world market.

(x) TOTAL FUNDING AND MRC CONTRIBUTION

The AMLRDC contributed $79,969.00between the 1986/1987 and 1990/1991 financial years. A conservative estimate of the financial contribution to the project by the Queensland Department of Primary Industries and CSIRO, Cannon Hill is $1.4M.

(xi) CONCLUSIONS AND RECOMMENDATIONS

* As expected, overall average daily gain increases with an improving nutritional regime and declines with increasing carcase weight, while age at turnoff increases with increasing carcase weight and decreases with improving nutrition.

* Growth rates required to achieve a younger turnoff off pasture at c. 30 months of age, in order to produce a product of perceived higher quality, are on average greater than those normally experienced in northern Australia.

- High input costs may be needed in order to attain target growth rates of steers off pasture for turnoff to meet perceived age/carcase weight criteria. The 'whole of life' grain feeding to produce steers for the Japanese market by approximately 27 months of age was uneconomic in this project.

- Increasing carcase weight influenced the carcase attributes of subcutaneous fat cover, dressing percentage and predicted yield of saleable meat. These attributes were unaffected by nutritional regime.

- The nutritional regime does not influence the nutritional status of the product, that is, dry matter content, fat content, marbling or protein content, however increasing carcase weight increases values of all these attributes.

- The total fat content of the *Longissimus dorsi* loin steaks was low, regardless of whether the *Bos indicus* cross steers had been ***grassfed*** or ***grainfed***.

- Pre-slaughter stress occurred in a number of turnoff groups associated with combinations of climatic factors (particularly high ambient temperature), management of animals prior to slaughter and increased holding times at meatworks prior to slaughter.

- Meat colour was influenced by an interaction between age at slaughter (affected by plane of nutrition) and carcase weight.

- On average, as determined by the objective (mechanical) measurement and subjective (sensory) evaluation of meat tenderness, the *Longissimus dorsi* steaks from *Bos indicus* cross steers were of average tenderness, with a small proportion very tender and a significant proportion very tough.

- Neither carcase weight nor the nutritional regime influenced the meat tenderness of *Longissimus dorsi* steaks as measured by objective (mechanical) methods.

- The majority (93%) of *Longissimus dorsi* (loin) steaks from the project were cold shortened (had shortened muscle sarcomeres) due to less than effective electrical stimulation following slaughter and a severe chilling regime.

- The majority of *Longissimus dorsi* steaks had high Instron compression values due to their connective tissue contribution and an overriding influence of cold shortening. Approximately half of the *Longissimus dorsi* steaks were considered tough due to their connective tissue contribution.

- As carcase weight increased, the sensory evaluated beef flavour and quality rating improved, while nutritional regime had no influence on these attributes.

- In *Longissimus dorsi* steaks from *Bos indicus* cross steers marbling rating had no influence on meat tenderness, measured either objectively (by mechanical means) or subjectively (through sensory evaluation), but had partial influence on beef flavour intensity. Total fat content of these steaks had partial influence on sensory evaluated tenderness and beef flavour intensity.

- The influence of pre-slaughter stress and the processing factors - electrical stimulation and chilling regime - are of greater importance than nutritional regime *per se* in affecting meat tenderness. These influences may override the effect of nutrition resulting in a lack of relationship between younger turnoff and improved tenderness.

- Hot standard carcase weight can be used to accurately predict subcutaneous fat cover, carcase length, carcase depth, and *Longissimus dorsi* steak marbling rating and fat content, but not eye muscle area.

- The measurement of subcutaneous fat cover at the rump site has the potential capability to accurately predict *Longissimus dorsi* marbling and fat content within this breed type.

* The dry matter content of *Longissimus dorsi* steaks can be used to accurately predict intramuscular fat content of those steaks.

The following recommendations are made:

* With an increasing emphasis on age/weight criteria to meet perceived market specifications, it is imperative that financial returns are commensaturate with the increased costs required to achieve these targets.

* For Australia to retain and increase market share, a consistently tender beef product can be achieved through emphasis on:

1. Education of all sectors of the industry into the ramifications of pre-slaughter stress.
2. Education of meatworks processors on the deleterious effects of certain processing factors, that is, less than effective electrical stimulation and cold (muscle) shortening.

* Animals of the type used, did not have high marbling scores. The wisdom of attempting to produce high marbling score is questioned.

* That any measurement or assessment of the overall meat tenderness of a carcase be based on the measurement of tenderness in at least two representative muscles of the carcase, for example, the *Longissimus dorsi* muscle which represents muscles free to shorten, and the *Semitendinosus* (ST) muscle which represents muscles restrained from shortening. The *Longissimus dorsi* and the *Semitendinosus* have low and high connective tissue contributions to toughness, respectively.

Recommendations for future work:

Heifers - The effect of postweaning nutrition on the meat quality of cull heifers requires investigation. Cull heifers constitute 10-30% of normal turnoff, however, there is little information on the growth and meat quality of heifers to meet most markets.

Tenderness - The present study showed that animal age had little effect on LD tenderness. It is likely that the age differences which occurred between animals on the extremes of the planes of nutrition, would have produced larger differences in tenderness of muscles with a greater connective tissue contribution to toughness, for example, the ST or *Semimembranosus* (SM). This proposition should be tested - differences in tenderness of SM or ST of animals raised on a low or very high plane of nutrition and slaughtered at one of two, extreme carcase weights (190 or 320 kg) should be evaluated. There would be justification in evaluating the influence of animal age on the tenderness of a large number of muscles on a smaller number of animals.

Meat colour - was a very important quality trait in the present study in one meatworks. It was shown that animal age and chilling rate were important factors influencing meat colour (animals with an intermediate age from the heaviest slaughter weight groups had the lightest meat colour). The chilling system used cooled carcases quickly. The interactions of animal age and slaughter weight should be evaluated at two chilling rates at least, to determine if the meat colour of slow growing animals can be beneficially influenced by a slower chilling rate.

The present data indicated that, without grain feeding or better pastures, cattle grown in northern Australia will not grow quickly enough to be slaughtered young enough (at 320 kg) to produce light coloured meat in the LD, at least not if their carcases are chilled according to Meat Order 250 (Anon, 1985). Slower chilling, although it may have some adverse affects, would be expected to lighten meat colour. As grain feeding is expensive, it is suggested that the economics (medium - long term) of grain feeding versus improving pastures in northern Australia (research and implementation costs) should be studied (including pasture conservation). The present study was with one breed-type, future studies should include two breed-types.

(xii) MEDIA COVERAGE

Copies of prepared and published press articles, plus open/field day handout material are attached as Appendix VIII.

(xiii) PUBLICATIONS

The influence of plane of nutrition *per se* on meat colour has been published in:

Shorthose, W.R. and Harris, P.V. (1991). Effects of growth and composition on meat quality. In Advances in Meat Science. (Editor: A.M. Pearson) 7:515-549.

(xiv) REFERENCES

Anon (1985). Export Control (Orders) Regulations. Orders No. 2 of 1985 - Meat Order 250. p. 88.

Winks, L.W. (1984). Cattle growth in the dry tropics of Australia. AMRC Review No. 45.

APPENDIX I

SCIENTIFIC SECTION

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Appendix I Scientific Section

1. METHODOLOGY

1.1 Location

The project was carried out at a number of locations. The project animals were located at the Queensland Department of Primary Industries (QDPI), Brigalow Research Station, via Theodore. All animals were slaughtered at Weddel (CQME), Rockhampton. Meat quality analysis of samples collected from the project animals was carried out at CSIRO, Meat Research Laboratory, Cannon Hill. Analyses of fat content in the meat samples was carried out by the Biochemistry Branch, QDPI, Animal Research Institute, Yeerongpilly. Sensory evaluation of meat samples was carried out at the QDPI, International Food Institute of Queensland (formerly Food Research and Technology Branch), Hamilton. The project was managed by the QDPI, Rockhampton.

1.2 Animals

There were 680 *Bos indicus* cross steers (50 to 75% Brahman content) in the project. In September 1986, 290 weaner steers of mean initial unfasted liveweight of 193.1 ± 18.9 kg (± SD) were allocated to draft 1. In draft 2, there were 390 weaner steers of an unfasted liveweight of 211.6 ± 22.2 kg (± SD) which commenced in July 1987.

1.3 Experimental design

There were two replications (drafts of animals) of three nutritional regimes by three target carcase weights with the intention of the design that target weight groups would average 185, 260 and 320 kg carcase weight. The nutritional regimes comprised combinations of differing annual nutritional levels between weaning and the final target carcase weight. The nutritional regimes were:

Low, Medium, High (LMH);
Medium, Medium, Medium (MMM);
High, High, High (HHH),

where the high (H) growth rate was 180 kg/year, Medium (M) growth - 130 kg/year and Low (L) growth - 80 kg/year which are illustrated in Figure 1. In draft 2 only, a very high growth rate (H^+ nutritional regime) was evaluated for each of the three target carcase weights. The target growth rate of the H^+ nutritional regime was 300 kg/year.

Within each draft, the animals were allocated by stratified randomisation on fasted liveweight; in draft 1 there were nine nutritional regimes by target carcase weight combinations and in draft 2, there were 12 nutritional regime by target weight combinations. A treatment regime by target weight combination constituted one cell (or one turnoff group). The 32 animals in each of these cells comprised two "slaughter groups" of 16 animals each.

At a target carcase weight, the heaviest two slaughter groups of 16 animals each. whose mean "estimated" carcase weight was closest to the target carcase weight, were consigned for turnoff to comprise a turnoff group of 32 head. These groups were slaughtered one day apart.

1.4 Management

The nutritional regimes were achieved through stocking rate adjustment, provision of legume augmented pastures and protein supplementation. In particular, high growth rates were achieved through low stocking rates (1 steer/2-3 ha), legume-augmented sown grass pastures and the provision of forage crops and postweaning protein supplements. Medium growth was achieved through a stocking rate of 1 steer/1-1.5 ha on less fertile soils. Low growth was achieved by stocking at a high rate of 1 steer/0.4 ha - sufficient to retard growth without causing any detriment to the welfare of the animals.

Unfasted liveweights were measured every three weeks to facilitate management decisions concerning nutritional levels and selection of groups for slaughter.

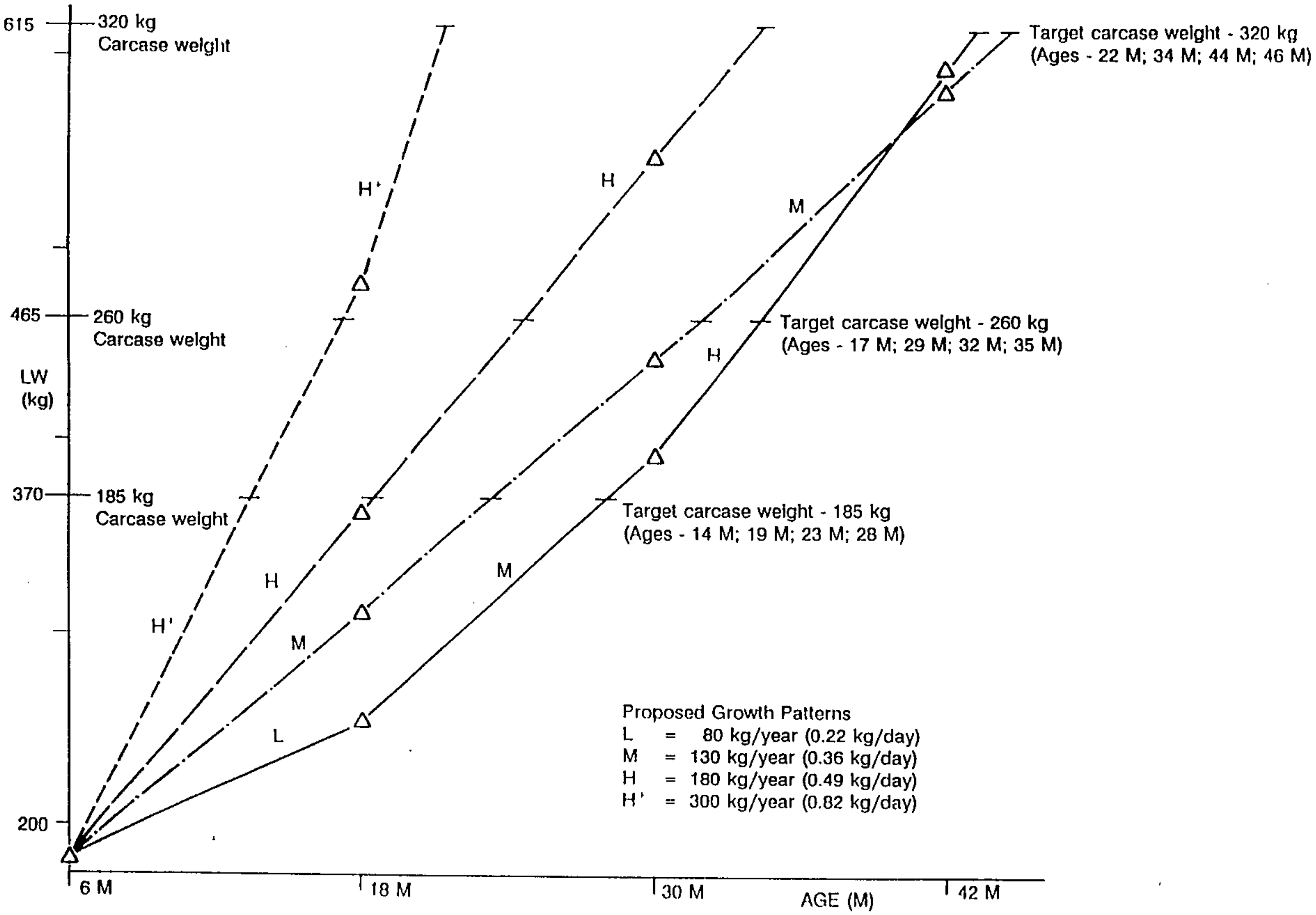

Figure 1 Projected growth patterns and target weights over time Brigalow Research Station

In draft 2, the very high growth rate of the H^+ nutritional regime was achieved by grain supplementation in the paddock, followed by a feedlotting phase for the 320 kg target carcase weight group only. The rations fed to the H^+ steers and the intakes recorded over the paddock supplementation phases are shown in Table 1. There were 32 steers in each target carcase weight turnoff group.

The 32 H^+ steers that were lotfed had been grain supplemented in the paddock for 418 days (Table 1). This group entered the feedlot in August 1988 and were fed for a further 145 days; these steers were to be slaughtered after 100 days but due to an unforeseen early closure of the meatworks in 1988, had to be held over in the feedlot for a further 45 days. Ration intakes approximated 14.5 kg/hd/d over the 145 days.

Table 1 Paddock supplementation rations and intakes of the very high nutrition (H^+) group

	Target turnoff carcase weight (kg)		
	185	260[1]	320[1]
Ration	Sorghum 4-5% protein meal 1% limestone 1% salt rumen modifier	Barley or sorghum 1% urea 1% lime 0.2% salt 0.2% gypsum rumen modifier	Barley or sorghum 1% urea 1% lime 0.2% salt 0.2% gypsum rumen modifier
No. days to turnoff	193	492	418[2]
Intake (kg/hd/d)	4.4	4.3	4.2

[1] Received the same ration as the 185 kg target group for the first 193 days.

[2] Number of days before feedlot entry.

The feedlot ration used in the project is shown in Table 2. Mean, unfasted liveweight, at entry into the feedlot was 450.9 kg. An initial ration of 50% grain concentrate : 50% roughage diet was fed for two days. From day three until completion, a 90% grain concentrate : 10% roughage diet was fed (Table 2).

Table 2 **Feedlot ration for the very high nutrition (H^-) group turned off at 320 kg target carcase weight**

Ingredient		Percentage of grain concentrate mixture
Grain (Sorghum or Barley)		89.6
Cotton Seed Meal		5.0
Bentonite		2.0
Limestone		1.0
Urea		1.0
Muriate of Potash		0.8
Salt		0.2
Gypsum		0.2
Vitamin Premix		500 g/tonne
Rumen Modifier	- Elancoban	125 g/tonne (Days 1-69)
	- Avotan	2 g/hd/d (Days 70-145)

During the first seven days of the 90:10 diet the level of bentonite was increased from 2% to 4%, then reduced to 2% and maintained at that level for the duration of feeding. Roughage used was sorghum hay. Dependent on the crude protein % (C.P.) of the grain, the C.P. of the grain concentrate mixture varied between 14.2% and 15.5%.

Animals were held during the experimental period in a common yard. A stocking density of 1 steer/13.8 m^2 was used over the initial 111 days. Torrential rain on day 111 led to the yard becoming a quagmire necessitating more area being made available.

1.5 Turnoff procedure

At turnoff a standard procedure was adopted (Figure 2). This varied for only two of the 42 slaughter groups. Slaughter groups were always held overnight with access to water and trucked by road from the same set of cattle yards to the cooperating meatworks in Rockhampton, a distance of 250 km. Slaughter groups were always scheduled to arrive at the meatworks by approximately 12.00 noon, at the latest, on the day preceding slaughter. The same livestock transport company and, where possible, the same stock trailers and drivers were used for all consignments. This varied for only four of the 42 slaughter group consignments. All slaughter groups were trucked in 'single deck' trailers

Procedure

Days pre slaughter							
Group 1	2	1	-		0		-
Group 2	3	2	-		1		0
Steps	• Muster turnoff group (n=32) • Record unfasted liveweight • Draft into two groups of 16 steers each • Group 1 retained in yards overnight with access to water • Group 2 returned to holding paddock	• Group 1 trucked to meatworks • Re muster group • Group 2 retained in yards overnight with access to water	• Group 1 at meatworks • Commence lairage, access to water until 3.00 pm	• Group 2 trucked to meatworks	• Group 1 slaughtered	• Group 2 arrive at meatworks • Commence lairage, access to water until 3.00 pm	• Group 2 slaughtered
Time	8.00 am	6.00 am	12.00 noon	6.00 am	7.00 am	12.00 noon	7.00 am

Figure 2 Turnoff procedure adopted for slaughter groups

with 'filler' animals included to constitute a normal load. The filler animals, where possible, were of the same sex, class and liveweight. In 10 of the 42 slaughter group consignments, 'filler' animals were non pregnant females, generally heifers. For steers approximating 185 kg carcase weight, 12 'filler' animals were included; for 260 kg carcase weight, eight 'filler' animals; and for steers of 320 kg carcase weight, four 'filler' animals.

Upon arrival at the meatworks, slaughter groups were held in gravel pens with access to water for approximately three hours, prior to commencing a lairage period of approximately 16-17 hours in concrete pens without access to feed or water. On some occasions (for seven out of the 42 slaughter groups) the holding period was extended due to the requirements of pesticide residue testing or for the requirement of a premature trucking departure time (12 hours earlier) due to impending wet weather. In these circumstances, roughage hay was offered and water was available to animals. The climatic conditions during the pre-slaughter period and at slaughter are shown in Appendix VII.

1.6 Slaughter/boning procedure

At slaughter (7.00-8.00 am), all carcases were electrically stimulated within 10 minutes of stunning with a Koch Britton unit utilising 36 V for a 40 second continuous cycle. Hot standard carcase side weight (AUS•MEAT), carcase length and depth using the ABCAM system (Anon 1984) and subcutaneous fat depth at the P8 rump site (AUS•MEAT) were measured on both sides of the carcase within 45 minutes of stunning. Following a chilling (minimum temperature -2°C) which was equivalent to that specified in AQIS Meat Order No 250 (Anon, 1985), carcase sides were de-boned (24 hours after death), eye muscle area measured at the quartering point and 1 kg and 0.5 kg samples of the 'cube roll' (*Longissimus dorsi*) were collected adjacent to the quartering point between the eighth and twelfth thoracic vertebrae. The quartering point varied with market destination. Slaughter groups averaging 185 kg carcase weight were quartered at the 12/13 rib, groups averaging 260 kg carcase weight at either the 10/11 rib or 12/13 rib depending on weight/grade, while groups averaging 320 kg carcase weight were quartered at the 10/11 rib. Samples were wrapped in plastic sheet, cartoned, blast frozen at -26°C then held in storage freezers at -18°C until transferred to Brisbane.

1.7 Data collection

The following measurements were made:

Unfasted liveweight - every three weeks and at turnoff
Climate data at each turnoff on Brigalow Research Station, and at the Rockhampton Meteorological Bureau.
At slaughter
- dentition
- hot standard carcase weight
- carcase dressing percentage
- subcutaneous fat depth at the P8 site
- carcase length
- carcase depth
- eye muscle area at quartering point

Meat quality analysis (of *Longissimus dorsi* lean meat samples)
- total fat content
- dry matter content
- marbling score (visual)
- cooking loss
- ultimate pH (>48 h post slaughter)
- surface muscle colour (Hunter 'L' value)
- sarcomere length
- Warner Bratzler (WB) Initial Yield values (IY)
- WB Peak Force (PF) values
- WB PF-IY
- WB Pressure Heat (PH) IY
- WB PH IY
- WB PH PF

- WB PH PF-IY
- Instron compression values

Sensory evaluation

- length of freezing
- drip loss
- juiciness
- flavour
- tenderness
- quality score

Full data collection was not always possible. Departures from normal collection were:

Draft 1	- 185 kg target carcase weight, LMH, MMM and HHH nutritional regimes, there was no data for carcase length, carcase depth and eye muscle area. There was no sensory evaluation data available for MMM and HHH nutritional regimes at this target carcase weight. - 260 kg target carcase weight, LMH group, no marbling data was available.
Draft 2	- 185 kg target carcase weight, MMM nutritional regime slaughter group 2 carcases boned out 96 hours post slaughter instead of 24 hours post slaughter due to an industrial dispute. No meat quality data was available.

One group, the LMH regime of draft 2 to be slaughtered at the 185 kg target carcase weight could not be slaughtered when scheduled at that target. Due to an early unplanned closure of the cooperating meatworks in 1988, this group was held over to late January 1989 and then slaughtered. Their actual carcase weight at slaughter was 201.5 kg.

1.8 Analytical procedure

Frozen 1 kg samples of the *Longissimus dorsi* (LD) in cartons were transported in commercial refrigerated transport from Weddel, Rockhampton to Brisbane and placed in a freezer upon arrival. These samples had been collected adjacent to the quartering point from one side of each project carcase.

A 100 g sample was sawn from the frozen LD before the samples were thawed at 5-6°C for 48 hours. These 100 g samples were finely minced, freeze dried, then Soxhlet extracted with petroleum ether (b.p. 40° - 60°) for 16 hours in order to determine total fat content. Marbling of the LD was visually assessed using a five point scale, while colour of the fresh cut meat surface (Hunter 'L' value) was determined using a Minolta CR200 Chromameter. LD ultimate pH values and sarcomere lengths of the LD samples were determined (Bouton *et al.* 1973) before weighed samples (approximately 200 g) were cooked in a water bath at 80°C for an hour. Cooking loss was determined following cooking. Cooked samples were stored overnight at 1°C before a minimum of six Warner Bratzler Shear and Instron compression values were determined (Bouton *et al.* 1971).

At sample collection, approximately 500 g of the cube roll, adjacent but distal to the main sample was selected at random from four steer carcases out of each slaughter group of 16 steer carcases. This resulted in eight samples per target weight by nutritional regime turnoff group of 32 animals. These samples, following collection, were handled in the same manner as the main sample (1 kg sections). After freezing, these 500 g samples were transported by air in dry ice to QDPI laboratories in Hamilton, Queensland, and stored at -18 C until required.

Cube roll sections were removed from frozen storage 20 hours before use in sensory evaluation panels. Cube roll sections were thawed at room temperature for four hours and subsequently at 12°C for 16 hours. The sections were trimmed of visual fat and, beginning from the distal end, 2 cm thick steaks were cut. Steaks were weighed prior to being cooked.

Steaks were cooked in a pre-warmed, fan-forced, gas oven at 200°C for 16 minutes, resulting in an internal temperature of approximately 68°C. After cooking, steaks were left at room temperature for one minute, weighed and cut into 1 by 1 by 2 cm cubes. Two meat cubes from different regions of each steak were wrapped in alfoil and placed into an insulated container.

Representative samples from each treatment group were evaluated, while warm, by up to 20 members of a trained descriptive panel (Cross *et al.* 1978) drawn from employees of the International Food Institute of Queensland. They used eight point descriptive scales for juiciness, tenderness, and an overall quality rating and a seven point descriptive scale for beef flavour (Coleman *et al.* 1988).

Panellists were presented with two meat sample cubes from each of four product treatments, identified by a one letter random code, at one sitting. Products were assessed under green light in individual tasting booths. Panellists were asked to mentally average the ratings for both cubes of each product treatment before recording scores.

1.9 Statistical analyses

The main effects of draft, nutritional regime, target carcase weight and the nutritional regime X target carcase weight interaction were fitted and tested in an analysis of variance (ANOVA) using the method of least squares (Harvey, 1964). In the ANOVA model, the two drafts were regarded as replicates/blocks and error was estimated from the residual variation amongst the 18 cells of the two drafts X three nutritional regimes X three target carcase weight table. In the original design, each turnoff group or cell - the experimental unit in this project - comprised 32 animals (two slaughter groups X 16 animals) but for various reasons there were unequal numbers of animals per cell at data analysis; for some measurements, cells were completely missing and for these a reduced ANOVA model was fitted using only non empty cells.

The ANOVA model for all 18 cells X 32 animals per cell was:

Drafts	1 d.f.
Nutritional regime (T)	2
Target carcase weight (W)	2
T x W	4
Error	8
(Animals within cells)	558

Means were compared using the protected LSD procedure at the 5% level of significance. In the tables of means, LSD values and significant testing have been given for main effect means only, even in the few cases where the nutritional regime X target carcase weight interaction was significant.

The covariate, ultimate pH, was fitted to the model for all meat quality parameters except protein content and taste panel parameters. This covariate was not significant and therefore not used in the final analysis. In the preliminary stages of the data analyses, slaughter group (day) was examined as a possible covariate but was found to be statistically unimportant.

The H^+ nutritional regime carried out in draft 2 only was not included in the ANOVA model.

Simple pairwise correlation coefficients were calculated from the cell means (of each draft, including the three H^+ cells of draft 2) rather than from individual animal data, since relationships were concerned with modelling the variation amongst cells. The relationships (based on cell means) were examined using standard linear and quadratic least squares regression techniques; equations were assessed for potential predictive capability using the *four times F rule* (Draper and Smith, 1966). However, equations claimed to have potential predictive power have not been validated with an independent data set.

The actual numbers in each turnoff group used for statistical analysis are shown in Appendices II to VI. There were missing cells for some carcase attributes. Some parameters were derived, these being:

- Predicted saleable meat yield (Y) in kg which was calculated from the prediction equation of R.F. Thornton *pers comm.*

$$Y = -6.32 + 0.633\,\text{HSCW} - 0.353\,\text{P8} + 0.348\,\text{EMA} \quad (100R^2 = 98\%, \text{RSD} = 6.49 \text{ kg})$$

where HSCW = hot standard carcase weight (kg)
P8 = rump fat thickness (mm)
EMA = eye muscle area at the tenth rib (cm^2)

The prediction of yield of saleable meat could not be carried out for draft 1, LMH, MMM and HHH 185 kg target weight groups, or the HHH 320 kg target carcase weight groups as eye muscle area was not measured for these groups.

- Protein content (%) = Dry matter (%) - Total fat content (%) (of lean meat sample)
- Drip loss (%) = ((Frozen weight - thawed weight)/frozen weight) x 100

For sensory evaluation, the tasting design was developed so that panellists received meat samples from four different cells (turnoff groups) at each sitting. This design resulted in the four meat samples from each cell being kept in frozen storage for various periods of time. It was assumed that the sensory panel rated consistently during the testing of samples for each draft.

For statistical analysis of the sensory evaluation parameters, the covariates of process day, internal cooking temperature and number of days frozen were fitted to the ANOVA model but only the covariate of number of days frozen was found to be significant ($P < 0.05$) for the attributes of drip loss and juiciness and was therefore included in the final ANOVA model.

2. RESULTS AND DISCUSSION

2.1 Growth and development

2.1.1 Seasonal conditions

Brigalow Research Station has a maximum average temperature of 33°C in summer while the minimum average temperature is 20.9°C in the same season. In winter, the maximum average temperature is 21.5°C and the minimum average is 6.1°C. Frosts are generally recorded between late May and September with a marked incidence in July and August. Pasture quality declines following frosting. The average annual rainfall is 747.6 mm.

The rainfall recorded over the project period is shown in Table 3. Rainfall was above average for two of the four years in this project. In most years, summer rainfall was below average and winter rainfall above average, especially in July. April and November rainfalls tended to be above average.

Table 3 **Monthly rainfall (mm) recorded at Brigalow Research Station between 1986/1987 and 1989/1990**

Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
1986-87	32.1	25.7	44.8	232.5	180.6	42.6	118.3	45.0	15.6	25.2	73.5	23.0	828.9
1987-88	53.6	9.0	12.0	83.6	120.1	64.9	57.4	49.5	38.8	84.1	27.6	27.2	627.8
1988-89	64.5	176.6	14.0	11.6	41.8	305.3	75.4	135.2	134.0	128.0	56.8	12.0	1155.2
1989-90	52.7	35.8	34.5	61.6	128.8	44.2	9.1	53.9	86.8	145.6	68.6	30.8	752.4
Mean	40.8	36.5	33.5	71.0	82.9	115.3	100.5	96.3	45.2	46.6	50.5	28.5	747.6

The absence of marked summer rainfall often results in lower pasture yields, which can be accounted for by adjusting stocking rates, while wet winters in this environment are often responsible for above average liveweight performance over winter.

2.1.2 Animal productivity

In this project, growth rates, estimated as average daily gains (ADG) reflect the various nutritional regimes. The growth rates relate more to the means of achieving the nutritional regime as a design variable and are not considered as a response variable *per se*. As the nutritional regime was improved, growth rates increased significantly ($P<0.05$) as shown in Table 4.

Table 4 Weaning to turnoff growth rates (kg/hd/d)[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.025
	185	**260**	**320**	
LMH	0.381	0.399	0.417	0.399^c
MMM	0.534	0.442	0.425	0.467^b
HHH	0.665	0.546	0.478	0.563^a
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.025	0.527^a	0.462^b	0.440^b	
H^+ NUTRITIONAL REGIME	0.743	0.578	0.652	
		Avge. SEM = ±0.018		

[1] The target carcase weight by nutritional treatment interaction was significant ($P<0.05$).

Growth rates decreased as target carcase weight increased. Growth rates to 185 kg target carcase weight were significantly greater ($P<0.05$) than growth rates to the 260 or 320 kg target carcase weight.

The H^+ growth rates are "descriptive" only in the sense that they cannot be compared statistically with the other nutritional regimes. The growth rate of the H^+ 320 kg target carcase weight group was greater than the H^+ 260 kg target. This reflects the grain lot feeding phase of this nutritional regime group, to the 320 kg target carcase weight. This H^+ 320 kg group were paddock grain supplemented for 418 days and recorded a growth rate (±SEM) of 0.572 ± 0.013 kg/hd/d; the same group recorded a growth rate (±SEM) of 0.883 ± 0.027 kg/hd/d for the ensuing 145 day period in the feedlot. Actual growth rate (±SEM) over the initial 100 day period was 1.169 ± 0.031 kg/hd/d and over the final 45 days was 0.247 ± 0.054 kg/hd/d. Liveweight gain over the first 100 days was considered commercially acceptable for *Bos indicus* cross steers in the absence of hormonal growth promotants. However, gain over the final 45 days was less than optimal and reflected prevailing hot, humid and wet conditions.

The actual growth rate of each target weight by nutritional regime group is shown in Table 4. These results suggest growth rates increase as nutrition improved at the 185 kg and 260 kg target carcase weight but growth rates were unaffected by nutritional regime at the 320 kg target. The interaction between nutritional regime and target carcase weight for overall growth rate was significant ($P<0.05$) and is illustrated graphically in Figure 3 (the H^+ groups have been included in Figure 3 for comparison). The interaction arises due to the lack of any significant difference ($P>0.05$) in growth rate between the LMH, MMM and HHH groups at the 320 kg target compared to the 185 kg and 260 kg targets. As stated previously, the growth rate of the H^+ nutritional regime groups was higher than the other nutritional regimes at each target weight.

The overall growth rate patterns recorded in this project are shown in Figure 4, and illustrate where the influences of nutritional regime are most apparent. In all cases, steers from a H^+ or HHH nutritional regime recorded higher growth rate to all carcase weights, but differences in growth rate between the LMH and MMM nutritional regimes were not great. This is also apparent from Table 4 and from Table 5, where the number of days to turnoff for each group is shown (days to turnoff reflect growth rates). Any differences between drafts in the number of days to turnoff at the same target carcase weight and from the same nutritional regime reflect final liveweight differences. The

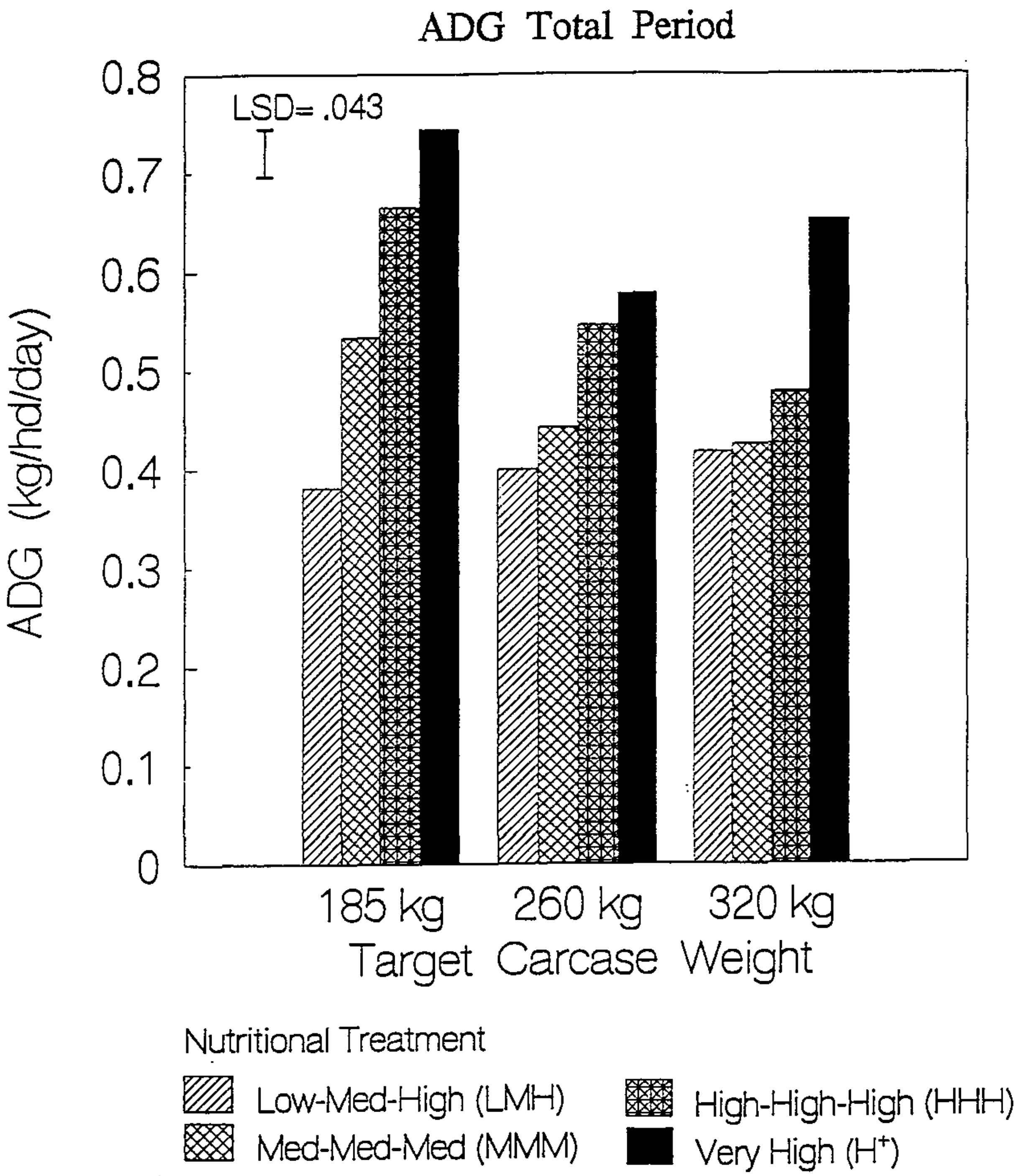

Figure 3 Interaction between nutritional regime (LMH, MMM, HHH) and target carcase weight on overall growth rate (plot of H^+ regime included for comparative purposes)

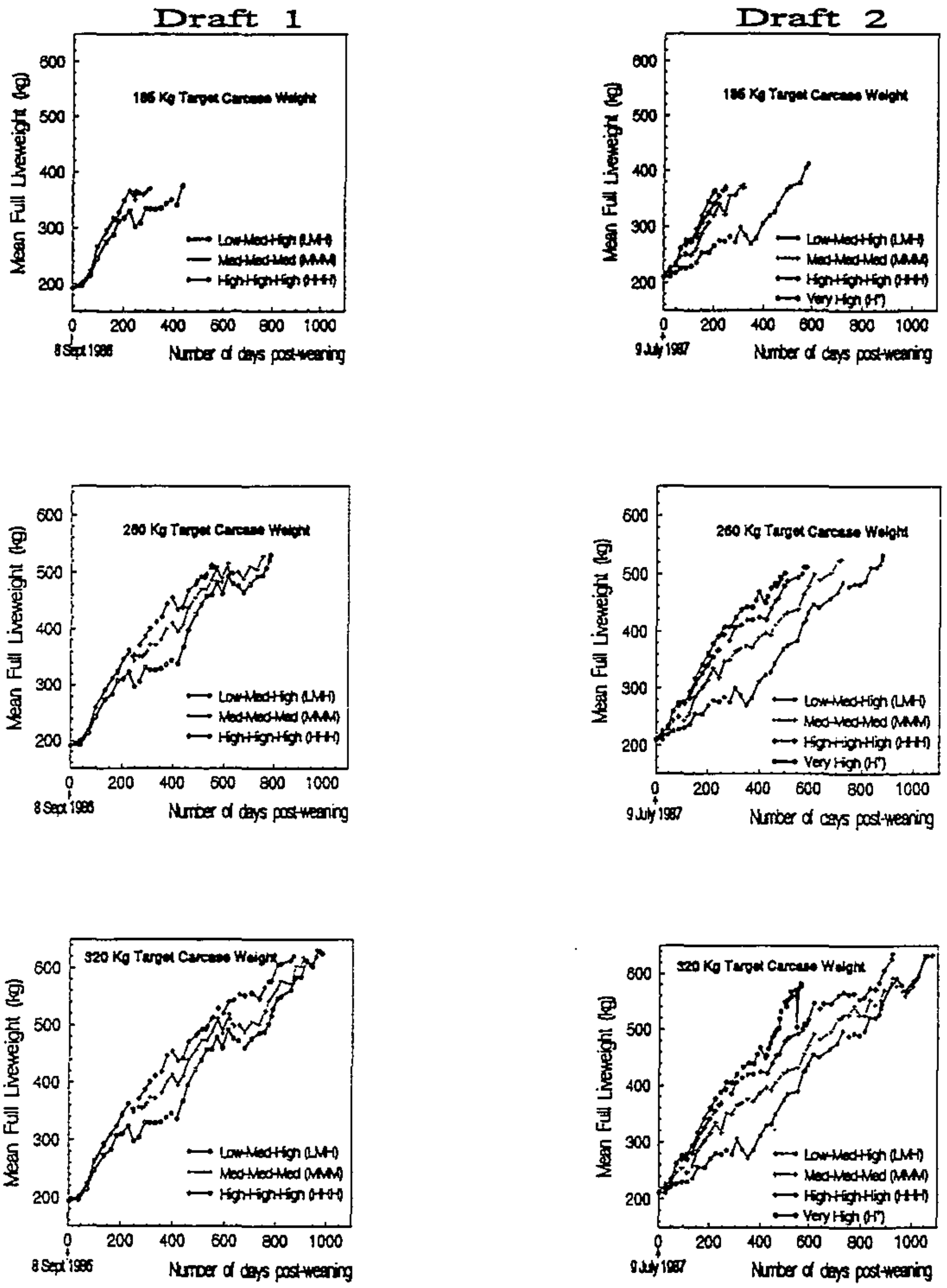

Figure 4 Growth rate patterns between weaning and turnoff for each nutritional regime at each target carcase weight

most striking result is the difference in days to turnoff between the H^+ group at 320 target carcase weight compared to the other nutritional regime groups at the same carcase weight. Within each target carcase weight, there were extremes in days to turnoff between the lowest and highest nutritional planes.

Table 5 **Number of days between commencement (weaning) and turnoff of each group**

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185	**260**	**320**
LMH			
Draft 1	439	783	979
Draft 2	584	878	1060
MMM			
Draft 1	307	755	909
Draft 2	319	717	1081
HHH			
Draft 1	251	552	867
Draft 2	248	584	920
H^-	205	500	563

One of the few attributes for which there was a significant difference ($P<0.05$) between drafts (years) was overall growth rate; the other attributes were final liveweight and predicted yield of saleable meat. Overall growth rates of drafts 1 and 2 were 0.503 and 0.450 kg/hd/d respectively. This difference cannot be easily explained, however Figure 4 suggests that differences in growth rate between each nutritional regime were much less in draft 1 compared to draft 2. Greater emphasis was placed on managing growth rates in draft 2 to achieve a greater separation between the nutritional regimes. Greater separation occurred between the lesser nutritional regimes and therefore the lower overall growth rates of draft 2 were expected.

Immediate pre-slaughter growth rate was investigated as it has been associated with pre-slaughter stress. Average daily gains recorded over the approximate 50 day pre-slaughter period are shown in Table 6. There were no significant differences ($P>0.05$) due to either of the main effects nor was the target weight by nutritional regime interaction significant ($P > 0.05$). The apparent differences may have resulted from compensatory gain following short term fluctuations in growth rate.

Table 6 **Average daily gain (kg/hd/d) recorded over the approximate 50 day pre slaughter period**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=0.370$
	185	**260**	**320**	
LMH	0.783	0.581	0.661	0.675
MMM	0.316	0.466	0.501	0.428
HHH	0.500	0.442	0.596	0.512
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.370$	0.533	0.496	0.586	
H^+ NUTRITIONAL REGIME	0.847	0.437	0.246	
	Avge. SEM = ±0.047			

Mean dentition (Table 7) indicates the approximate age at slaughter and reflects growth rate. Both the main effects of nutritional regime and target carcase weight were significant ($P < 0.05$), while the interaction was not significant ($P > 0.05$).

As the nutritional regime was improved the number of permanent teeth at slaughter declined significantly.

As expected, the number of permanent teeth increased significantly as the target carcase weight increased. The H^+ nutritional regime data indicates a similar trend in dentition to the main effect of target carcase weight though with less separation between means. The complete spectrum of dentition was recorded in this project.

Table 7 Mean dentition (number of permanent teeth) at turnoff

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=0.56$
	185	**260**	**320**	
LMH	1.63	4.94	6.50	4.35^{a}
MMM	0.09	4.04	6.39	3.51^{b}
HHH	0.13	2.45	5.68	2.75^{c}
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.56$	0.61^{c}	3.81^{b}	6.19^{a}	
H^{+} NUTRITIONAL REGIME	0.00	1.93 Avge. SEM = ±0.14	2.83	

Overall, the differences between nutritional regimes in growth rate to each target carcase weight were not as great as desired. The desired growth rates for the project are shown in Figure 1. At times there was little difference in growth between the LMH and MMM nutritional regimes, especially to the 260 kg target carcase weight, while differences between all the nutritional regimes to 320 kg, except the H^{+}, were marginal. When the H^{+} results are included in addition to the other nutritional regimes, there were marked differences in growth rate achieved between the lowest and highest nutritional planes in the project.

The project has generated useful data on *Bos indicus* steer growth which has direct commercial application.

Based on the data from this project we suggest that the minimum growth rates of steers between weaning (200 kg LW) and turnoff required for specific markets are:

Australian domestic carcases
(Average 185 kg HSCW) - 0.75 kg/hd/d
for 12-15 month old turnoff

Korean carcases
(Average 260 kg HSCW) - 0.35 kg/hd/d
for 3 year old turnoff

Japanese carcases
(Average 320 kg HSCW)
for -

- **2 year old turnoff - 0.75 kg/hd/d**
- **2½ year old turnoff - 0.60 kg/hd/d**
- **3 year old turnoff - 0.45 kg/hd/d**

These descriptive data highlight the magnitude of growth rates required for younger turnoff particularly for the production of steers suitable for the Japanese market. The target growth rates as indicated above, are far greater than the average annual growth rate (approximating 0.27 kg/hd/d) off grass pastures in northern Australia. This indicates that many areas of that region would be incapable of producing steers to meet these criteria. In the Brigalow region of Queensland, in which this project was conducted, average annual growth rates approximate 0.45 kg/hd/d, indicating that three year old turnoff for the Japanese market is achievable off grass pastures systems in that region without further inputs. To achieve younger turnoff for the same markets in the Brigalow region or in regions of similar productivity, further inputs to boost productivity are required. Likely inputs include pasture improvement or production feeding strategies. The costs associated with younger turnoff for this market are discussed later in the report.

2.2 Carcase attributes

2.2.1 Final liveweight, carcase weight and dressing percentage

The attributes, final or turnoff liveweight, carcase weight and dressing percentage reported in Tables 8 to 10 respectively are inter-dependent and are discussed collectively. In this project, target carcase weight was a design variable, that is, the nutritional regimes were managed to achieve a final liveweight which was as close as possible to a target carcase weight. To achieve this carcase weight, the correct final liveweight had to be achieved. Dressing percentage influenced the choice of this final liveweight as dressing percentage changes with carcase weight and was expected to change with nutritional regime.

Table 8 Turnoff unfasted liveweight (kg)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=11.9$
	185	**260**	**320**	
LMH	394.1	531.9	628.6	518.2^{a}
MMM	370.2	526.4	624.1	506.9^{ab}
HHH	368.0	510.9	628.7	502.5^{b}
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=11.9$	377.5^{c}	523.0^{b}	627.1^{a}	
H^{+} NUTRITIONAL REGIME	363.7	501.9	578.8	
		Avge. SEM = ±8.4		

As expected, final liveweight (Table 8) and carcase weight (Table 9) increased significantly ($P<0.05$) as target carcase weight increased.

Table 9 Hot standard carcase weight (kg)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =6.9
	185	260	320	
LMH	193.3	272.5	331.8	265.7
MMM	180.0	271.1	322.7	257.9
HHH	183.3	268.2	328.0	259.8
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =6.9	185.6^c	270.6^b	327.5^a	
H^+ NUTRITIONAL REGIME	182.2	268.3	316.9	
	Avge. SEM = ±4.9			

Dressing percentage (Table 10) also increased as target carcase weight increased with dressing percentages at 260 kg and 320 kg targets significantly higher ($P<0.05$) than at the 185 kg target. There was no significant difference ($P>0.05$) in dressing percentage between the 260 and 320 kg targets. Increasing dressing percentage as the target carcase weight increased was indicated for the H^+ nutritional regime.

Table 10 Carcase dressing percentage (%)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	**TARGET CARCASE WEIGHT**			**NUTRITIONAL REGIME MAIN EFFECT** Avge. LSD ($P=0.05$) $=0.78$
	185	**260**	**320**	
LMH	49.06	51.26	52.78	51.03
MMM	48.64	51.55	51.73	50.64
HHH	49.83	52.51	52.19	51.51
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.78$	49.18^b	51.77^a	52.23^a	
H^+ NUTRITIONAL REGIME	50.02	53.43	54.77	
		Avge. SEM = ±0.35		

The final (turnoff) liveweight of the LMH group was significantly higher ($P<0.05$) than for the MMM or HHH groups. There was no significant difference ($P>0.05$) in carcase weight or dressing percentage between the nutritional regimes. However, there was a non-significant trend for carcase weight and dressing percentage to increase as the nutrition improved - HHH > LMH > MMM. The trend of LMH > MMM was by design, as a high growth rate was required in the final annual phase of the LMH nutritional regime (see Figure 1).

The target carcase weight by nutritional regime interaction was not significant ($P>0.05$) for any of the attributes - final liveweight, carcase weight or dressing percentage.

The main effect of animal year draft on final liveweight was significant ($P<0.05$) with values of 504.3 kg and 514.1 kg for drafts 1 and 2 respectively. This difference cannot be explained. There was no corresponding difference between drafts in carcase weight or dressing percentage - a desired result.

An important feature of this large experiment was the unusual precision with which target carcase weights, across nutritional regimes and within each target carcase weight, were met in practice.

2.2.2 *Subcutaneous fat depth*

There was no significant ($P>0.05$) nutritional regime main effect on rump fat depth (Table 11).

Table 11 Effect of postweaning nutrition on subcutaneous rump fat (P8 site) depth (mm)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =2.01
	185	260	320	
LMH	6.57	12.34	20.51	13.14
MMM	5.72	10.77	19.30	11.93
HHH	7.39	16.65	17.75	13.93
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =2.01	6.56^{c}	13.25^{b}	19.19^{a}	
H^{+} NUTRITIONAL REGIME	8.42	13.12	19.92	
		Avge. SEM = ±0.75		

The LMH and HHH groups had recorded a marginally, but non-significantly ($P>0.05$) higher rump fat depth. Rump fat depth increased significantly ($P<0.05$) with increasing target carcase weight. The target carcase weight by nutritional regime ($P>0.05$) interaction was not significant. The data for the H^+ nutritional regime indicated an increase in fat depth with increasing target carcase weight.

In Figure 5, the strong positive linear relationship between rump fat depth and carcase weight ($100r^2 = 87\%$, $P<0.01$) is shown; rump fat depth increased linearly with increasing target carcase weight. The equation for this relationship (based on cell mean data) has potential predictive capability. All relationships described are based on a maximum of 21 cell means. Cell means represent the groups from each nutritional regime, target carcase weight and animal draft, plus the three target carcase weight groups of the H^+ nutritional regime of draft 2.

There was little difference indicated in rump fat depth between the H^+ nutritional regime (all *grainfed* groups) compared to the *grassfed* groups (LMH, MMM and HHH nutritional regimes).

The lack of a difference in subcutaneous fat depth was expected but would be contrary to the expectations of many beef producers. Rump fat depth over all the project animals (population mean carcase weight of 261.2 kg and rump fat depth of 13.00 mm) had a coefficient of variation (based on between animal variation) of 31%. Mean fat depths recorded for the 185 kg and 320 kg target weight groups fall into the range required for the Australian domestic and Japanese *grainfed* markets. However, due to the high coefficient of variation associated with this attribute, 8.7% of carcases had more rump fat depth (>22 mm) than desired for the Japanese *grassfed* market.

2.2.3 Carcase length, carcase depth and eye muscle area

Mean carcase length, carcase depth and eye muscle area were collected for all draft 2 and most draft 1 turnoffs. Data is not available for the 185 kg target carcase weight groups in draft 1 for these attributes.

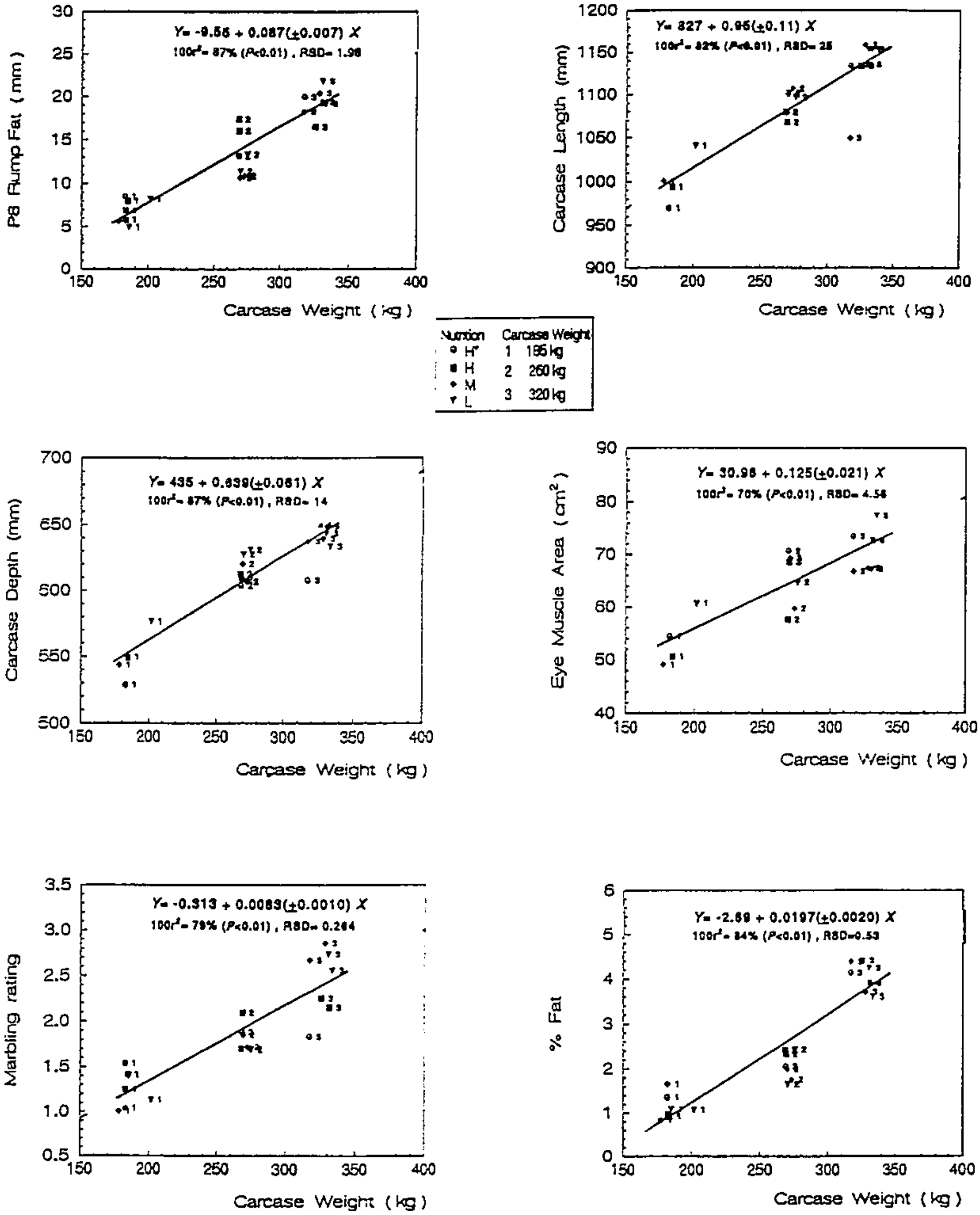

Figure 5 Linear regression between hot standard carcase weight and the carcase attributes of P8 rump fat, carcase length, eye muscle area, marbling and fat content (% fat) of *Longissimus dorsi* steaks

These attributes are considered as a likely indication of whether the increase in carcase weight is a result of increased skeletal growth or muscle growth, that is, compositional changes.

Nutritional regime had no significant ($P>0.05$) effect on carcase length (Table 12), or depth (Table 13), or eye muscle area (Table 14), nor were there any apparent trends due to nutritional regime.

Carcase length (Table 12) increased as target carcase weight increased from 260 kg to 320 kg though not significantly ($P>0.05$). The target carcase weight by nutritional regime interaction was not significant ($P>0.05$). For the H^+ nutritional regime also, indications are that carcase length increased as the target carcase weight increased. The mean carcase lengths of the 185 kg target carcase weight groups, draft 2, were 1041 mm, 1001 mm and 994 mm (±SEM 5 mm) for the LMH, MMM and HHH nutritional regimes respectively, suggesting that carcase length reduced as the nutrition was improved.

Table 12 **Effect of postweaning nutrition on carcase length (mm)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =60
	185	260	320	
LMH	-	1100	1154	1127
MMM	-	1105	1105	1105
HHH	-	1074	1134	1104
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =49	-	1093	1131	
H^+ NUTRITIONAL REGIME	970	1080	1099	
		Avge. SEM = ±7		

Figure 5 shows the positive linear relationship between carcase length and carcase weight ($100r^2 = 82\%$, $P<0.01$) based on cell means.

Carcase depth (Table 13) at the 320 kg target carcase weight was significantly greater than at the 260 kg target carcase weight ($P<0.05$). The interaction between target carcase weight and nutritional regime was significant ($P<0.05$) for carcase depth. In the H^+ nutritional regime groups, there was a tendency towards carcases of greater depth as the target carcase weight increased.

Table 13 Effect of postweaning nutrition on carcase depth (mm)[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=10$
	185	**260**	**320**	
LMH	-	630	639	634
MMM	-	613	639	626
HHH	-	611	650	630
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=8$	-	618^b	643^a	
H^+ NUTRITIONAL REGIME	528	604	608	
		Avge. SEM = ±4		

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[1] The target carcase weight by nutritional treatment was significant ($P<0.05$).

The mean carcase depth of the draft 2, 185 kg target carcase weight groups were 576 mm, 543 mm and 549 mm (±SEM 4 mm) for the LMH, MMM and HHH regimes respectively, suggesting a consistent effect of plane of nutrition.

There was a strong positive linear relationship between carcase depth and carcase weight ($100r^2 = 87\%$, $P<0.01$) based on cell means (Figure 5).

The difference in eye muscle area between 260 kg and 320 kg target carcase weight (Table 14) was not significant ($P>0.05$). The target carcase weight by nutritional regime interaction was not significant ($P>0.05$). There was a trend of increasing eye muscle area as the target carcase weight increased for the H^+ nutritional regime.

Table 14 Effect of postweaning nutrition on eye muscle area (cm^2)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=10.6$
	185	260	320	
LMH	-	66.8	72.2	69.5
MMM	-	64.5	67.1	65.8
HHH	-	63.2	75.4	69.3
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=8.7$	-	64.9	71.6	
H^+ NUTRITIONAL REGIME	54.4	70.7	73.5	
	Avge. SEM = ±1.7			

The mean eye muscle area of the draft 2, 185 kg target carcase weight groups were 60.7 cm^2, 49.1 cm^2 and 50.6 cm^2 (±SEM 1.2 cm^2) for the LMH, MMM and HHH regimes respectively. Eye muscle area is one of the few attributes in this project that was influenced by the heavier than desired carcase weight of the draft 2 LMH group that were slaughtered at 202 kg, rather than at the target of 185 kg.

The relationship between eye muscle area and carcase weight ($100r^2 = 70\%$, $P<0.01$) based on cell means is shown in Figure 5. Eye muscle area increased as target carcase weight increased.

2.2.4 Predicted yield of saleable meat

As the direct measurement of saleable meat yield was not possible in this project, a prediction of yield has been made (Table 15).

Table 15 Effect of postweaning nutrition on predicted[1] yield of saleable meat (kg)[2]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=4.0$
	185	**260**	**320**	
LMH	-	185.1	221.6	203.3
MMM	-	183.9	214.5	199.2
HHH	-	179.6	223.8	201.7
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=3.3$	-	182.9^b	219.9^a	
H^+ NUTRITIONAL REGIME	125.2	184.4	212.8	
		Avge. SEM = ±3.3		

---

[1] Prediction equation of R.F. Thornton *pers comm*

$$Y = -6.32 + 0.633HSCW - 0.353P8 + 0.348EMA \quad (R^2 = 0.980, SEE = 6.49 \text{ kg})$$

where HSCW = hot standard carcase weight (kg)

P8 = rump fat thickness (mm)

EMA = eye muscle area at the tenth rib (cm^2).

[2] The target carcase weight by nutritional treatment interaction was significant ($P<0.05$).

The main effect of nutritional regime on predicted yield of saleable meat was not significant ($P > 0.05$), however, the yield of carcases at the 320 kg target carcase weight was significantly greater ($P < 0.05$) than at the 260 kg target carcase weight.

The interaction between target carcase weight and nutritional regime for predicted yield was significant ($P < 0.05$) and arose because of the unexpectedly low value of the MMM 320 kg group.

The predicted yields of saleable meat of the H^+ nutritional regime group increased as the target carcase weight increased. The mean predicted yield of saleable meat of the draft 2, 185 kg target carcase weight groups were 139.5 kg, 121.2 kg and 125.0 kg (±SEM 1.9 kg) for the LMH, MMM and HHH nutritional regimes respectively. The higher predicted yield of the draft 2, LMH group was due to the higher than desired carcase weight of this group. Because of this higher turnoff weight, there was a significant difference ($P < 0.05$) between the yields of year draft 1 animals (199.4 kg) compared to the draft 2 animals (203.4 kg).

The difference in predicted yields of saleable meat between the target carcase weights of the H^+ nutritional regimes is interesting. The differences in carcase weight and predicted yield of saleable meat between the 185 kg and 260 kg targets were 86.1 kg, and 59.2 kg respectively, while between the targets of 260 and 320 kg the actual differences were 48.6 kg and 28.4 kg respectively. When the increase in predicted yield is expressed as a percentage of the actual increase in carcase weight the results were 69% and 58% respectively. This indicates the greater potential to increase yield of saleable meat at lower carcase weights, where the influence of carcase fatness is not as great.

2.3 Meat attributes

The target carcase weight by nutritional regime interaction was never significant ($P > 0.05$) for any of the following meat attributes.

2.3.1 Dry matter content

The main effect of nutritional regime on dry matter content of the LD samples (Table 16) was not significant ($P>0.05$). Dry matter content increased significantly ($P<0.05$) as the target carcase weight increased. A similar trend was indicated across target carcase weights for the H^+ nutritional regime.

Table 16 **Effect of postweaning nutrition on *Longissimus dorsi* dry matter content (%)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.49
	185	260	320	
LMH	23.37	24.47	26.17	24.67
MMM	24.76	24.67	26.26	25.23
HHH	23.84	25.19	26.50	25.18
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.49	23.99^c	24.78^b	26.31^a	
H^+ NUTRITIONAL REGIME	23.25	24.50	26.32	
		Avge. SEM = ±0.19		

2.3.2 Fat content

Nutritional regime had no significant effect ($P>0.05$) on the total fat content of the lean (denuded of all surface fat) LD samples, however fat content increased significantly ($P<0.05$) as the target carcase weight increased (Table 17).

Table 17 **Effect of postweaning nutrition on *Longissimus dorsi* total fat content (%)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=0.50$
	185	260	320	
LMH	1.09	2.00	3.94	2.34
MMM	1.38	1.87	4.05	2.43
HHH	0.96	2.38	4.19	2.51
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.50$	1.14^c	2.09^b	4.06^a	
H^+ NUTRITIONAL REGIME	1.36	2.06	4.14	
		Avge. SEM = ±0.17		

A similar trend was indicated across the target carcase weights for the H^- nutritional regime.

There are three main points regarding intramuscular fat content measured in the LD steaks from the Brahman cross animals in this project: the content is low, the content is unaffected by nutritional regime and the degree of variation in content.

Of great consumer importance was the low fat content of the LD steaks collected from the project Brahman cross animals.

There was no difference in fat content of the LD samples between the LMH, MMM and HHH nutritional regimes (all *grassfed* steers) and the H^+ regime (all *grainfed* steers).

Even though it was not statistically tested, there is no apparent difference between the fat content of the 320 kg target carcase ***grassfed*** weight groups (4.06%) and that of the H^+ group at the 320 kg carcase weight (4.14%) which had been lot fed. There was considerable variation associated with this attribute; the coefficient of variation was 40.8%. This variation may have a genetic basis.

There are a number of relationships involving fat content which require comment. The relationship between carcase weight and fat content based on cell means is positive ($100r^2=84\%$, $P<0.01$)and linear (Figure 5). This relationship has significant commercial significance, as it suggests that carcase weight can be used to estimate intramuscular fat content. Similarly, there is a strong positive ($100r^2=84\%$, $P<0.01$),linear, (Figure 6) relationship based on cell means between rump fat depth and fat content in the steak, within these genetically similar animals. Although this relationship has potential predictive capability, the measurement of rump fat for this prediction may not be a commercially practical alternative to the measurement of carcase weight.

The relationship between dry matter content and fat content has significant application for laboratory and commercial purposes. This relationship based on cell means is positive ($100r^2=89\%$, $P<0.01$),linear (Figure 7), and has predictive capability. A dry matter determination of lean meat steak is simple and far less costly than a chemical fat content determination and for this reason is widely used in meatworks.

2.3.3 Marbling score

There was no significant ($P>0.05$) effect of nutritional regime on marbling score. However, marbling score increased significantly ($P<0.05$) as the target carcase weight increased (Table 18).

On the five point rating scale used in this project, marbling was minimal at the 185 kg carcase weight and average at 320 kg carcase weight. Marbling, like all other carcase fatness related attributes, has a high coefficient of variation (38.4%) indicating that some individual animals had high marbling scores ($\geq$ score of 4).

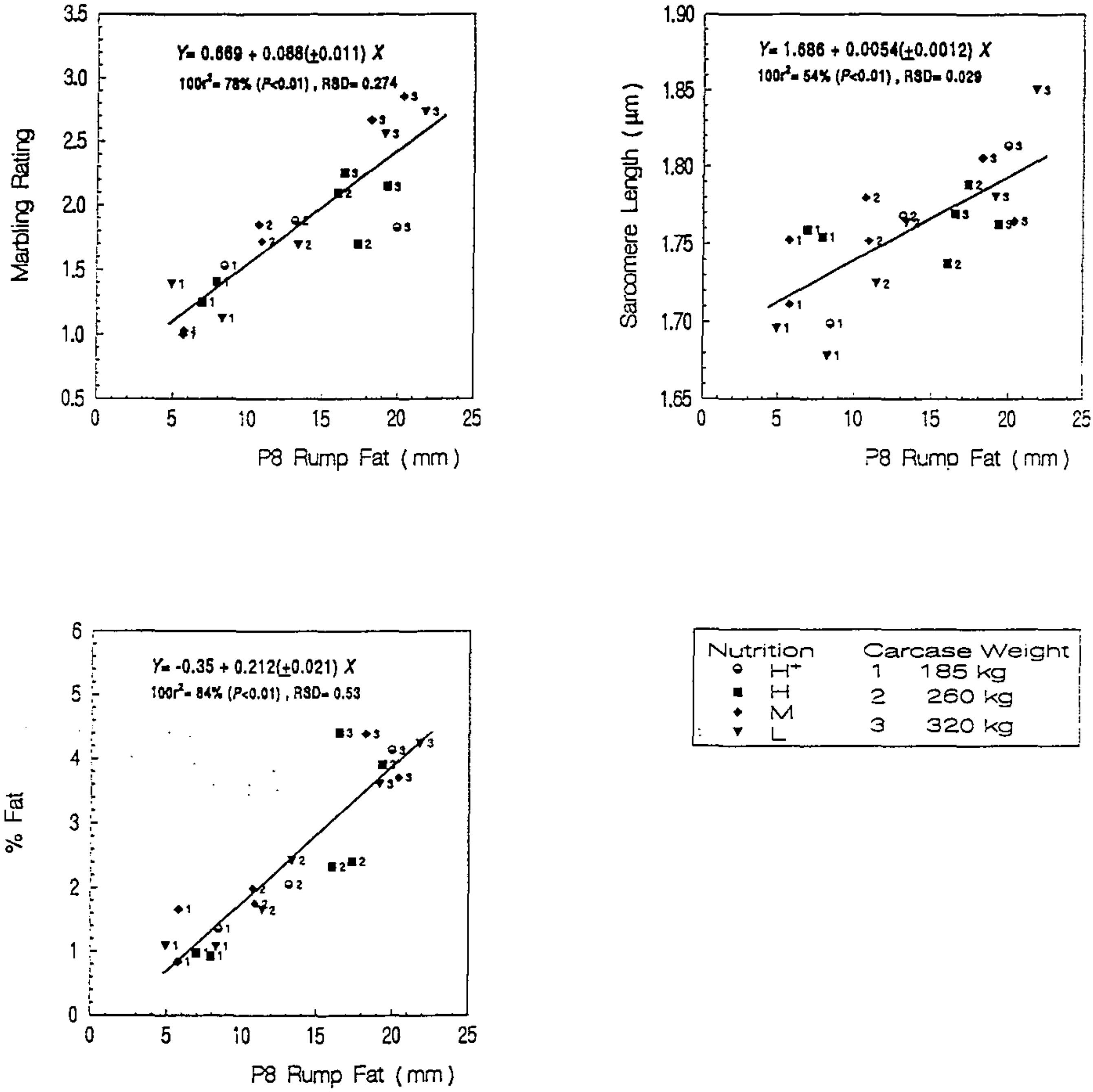

Figure 6 Linear regression between P8 rump fat and marbling, sarcomere length and fat content (% fat) of *Longissimus dorsi* steaks

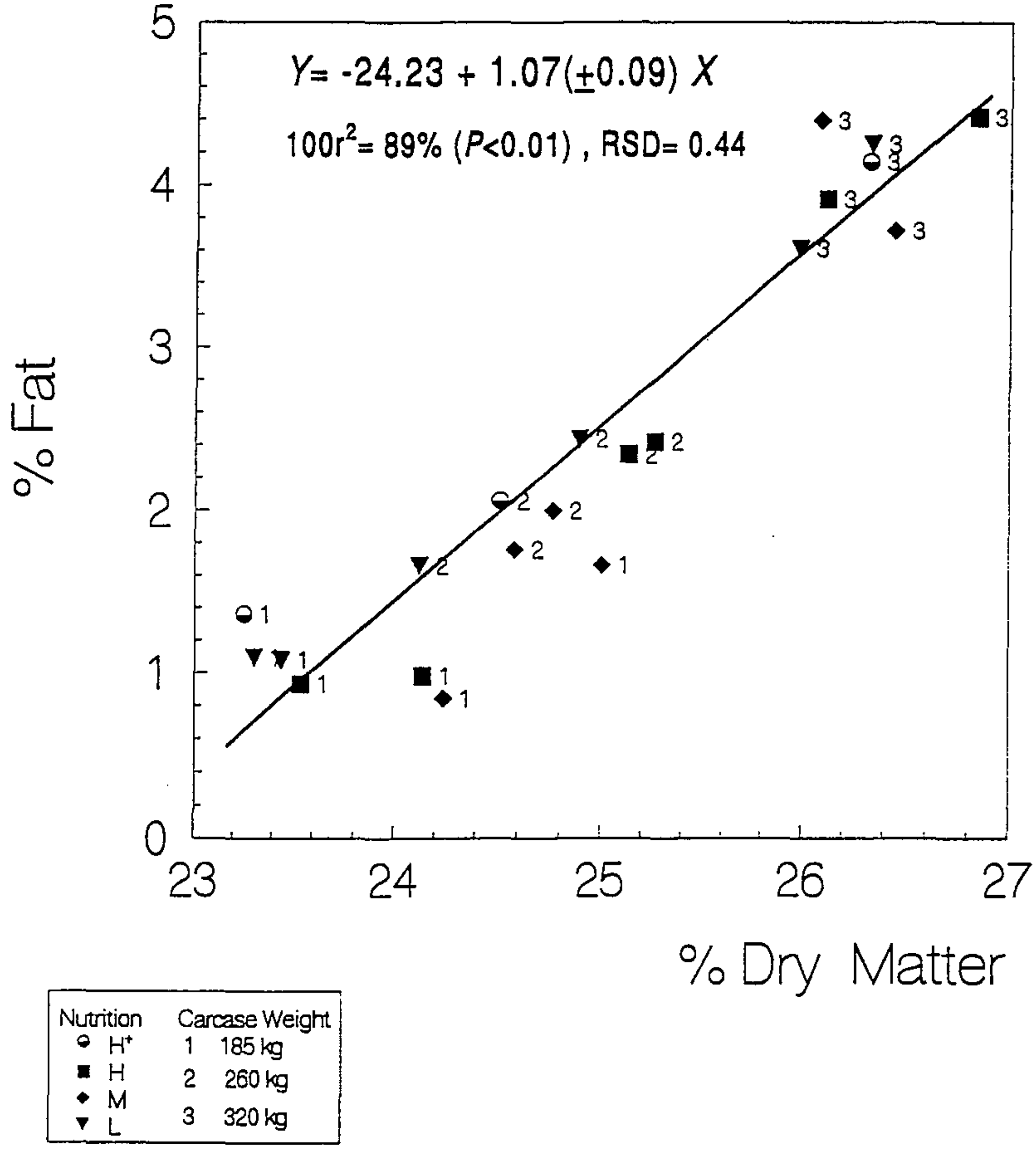

Figure 7 Linear regression between dry matter content and fat content (% fat) of *Longissimus dorsi* steaks

Table 18 Effect of postweaning nutrition on *Longissimus dorsi* marbling score[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=0.301$
	185	**260**	**320**	
LMH	1.258	1.633	2.652	1.848
MMM	1.041	1.784	2.565	1.796
HHH	1.328	1.901	2.198	1.809
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.301$	1.209^c	1.773^b	2.472^a	
H^+ NUTRITIONAL REGIME	1.531	1.880	1.825	
		Avge. SEM = ±0.114		

[1] Subjective rating of visual intramuscular fat content on a scale of 1-5, with 1=nil and 5=heavy marbling.

For the H^+ nutritional regime data, indications are that marbling does not increase as markedly with increasing target carcase weight, compared with the main effect means and for H^+, the means are middle order.

There was little difference in marbling score between any of the *grassfed* groups (LMH, MMM and HHH nutritional regime) and the *grainfed* groups (H^+ nutritional regime), at 185 and 260 kg target carcase weights, however, at the 320 kg target, there is indication of the H^+ marbling score being lower than the *grassfed* groups.

The relationship between carcase weight and marbling (Figure 5) based on cell means is positive and linear ($100r^2=79\%$, $P<0.01$). Marbling score also increases with increasing rump fat depth, as shown in Figure 6. This relationship based on cell means is also positive and linear ($100r^2=78\%$, $P<0.01$) and is a possible alternative for prediction of marbling other than carcase weight. Fat content and marbling were significantly related ($100r^2=74\%$, $P<0.01$),suggesting that marbling score should increase as fat content increases.

From this project it is clear that increasing carcase weight had the greatest influence on carcase fatness (attributes - rump fat depth, LD steak fat content and marbling score), whereas nutritional regime had little influence.

2.3.4 Protein content

The main effect of nutritional regime on protein content was not significant ($P>0.05$), while the effect of target carcase weight on protein content was significant ($P<0.05$) (Table 19).

Table 19 Effect of postweaning nutrition on *Longissmus dorsi* protein content (%)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.40
	185	260	320	
LMH	22.28	22.46	22.23	22.32
MMM	23.38	22.79	22.21	22.79
HHH	22.89	22.81	22.32	22.67
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.40	22.85^a	22.69^a	22.25^b	
H^+ NUTRITIONAL REGIME	21.88	22.44	22.19	
	Avge. SEM = ±0.15			

The data for this attribute suggests that protein content declined very marginally as the target carcase weight increased.

2.3.5 Ultimate pH

The HHH nutritional regime recorded a significantly higher (P=0.05) mean ultimate pH value than either the MMM or LMH regimes (Table 20).

Table 20 Effect of postweaning nutrition on *Longissimus dorsi* ultimate pH values[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly (P>0.05). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.078
	185	**260**	**320**	
LMH	5.613	5.578	5.555	5.582^b
MMM	5.604	5.560	5.581	5.582^b
HHH	5.686	5.626	5.692	5.668^a
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.078	5.635	5.588	5.609	
H^+ NUTRITIONAL REGIME	5.724	5.535	5.620	
	Avge. SEM = ±0.024			

[1] Nutritional regime main effect significantly different at P=0.05, not P<0.05.

There was no effect of target carcase weight on ultimate pH nor were there any apparent trends.

The majority of turnoff groups had mean ultimate pH values that fell in the acceptable range (5.6-5.7).

Ultimate pH values less than 5.6 are considered ideal, while values ≥5.7 are unacceptable indicating pre-slaughter stress has occurred. Dark cutting is recorded when ultimate pH values are ≥5.8. The distribution of ultimate pH values of all individual animals is shown in Figure 8. This distribution indicates the normality of this parameter with a slight positive skewness. In this data set, the majority of samples were less than 5.80 with only 3% of samples having ultimate pH values greater than 5.80. From analysis of this frequency distribution, 80% of the population (the 80th percentile) had ultimate pH values less than 5.68, confirming that most samples fell in the normal acceptable range. Some turnoff groups had higher mean ultimate pH values than others, in particular, the HHH 185, HHH 320 and H^+ 185 groups.

The higher values of the HHH 185 kg group were recorded in the draft 2 (5.726) turnoff and in draft 1 of the HHH 320 kg turnoff (5.724). As these turnoff groups plus the H^+ 185 group (draft 2 only, Table 20) all had mean ultimate pH greater than 5.70 we suggest that pre-slaughter stress occurred in these groups. We conclude that the common possible causative factors implicated in pre-slaughter stress in this project were high ambient temperatures near, or at slaughter (refer to Appendix VII), additional holding time at the meatworks required for pesticide residue testing, mixing with unfamiliar animals prior to transport, and the use of heifers as transport fillers. None of these factors occurred in isolation, but always in some combination, therefore it is not possible to identify the individual factors responsible for pre-slaughter stress in this project. Sudden changes in ambient temperature before trucking or during trucking were not associated with pre-slaughter stress (increased ultimate pH). The correlation analysis carried out for this project indicates that none of the live animal parameters measured, showed any relationship with ultimate pH, therefore it is not possible to indicate causes of pre-slaughter stress, apart from the climatic and management factors mentioned previously. The approximate 50 day pre-slaughter growth rate was tested as a possible measure of pre-slaughter stress, however, there was no relationship between the 50 day ADG and ultimate pH ($100r^2=4\%$, n.s.).

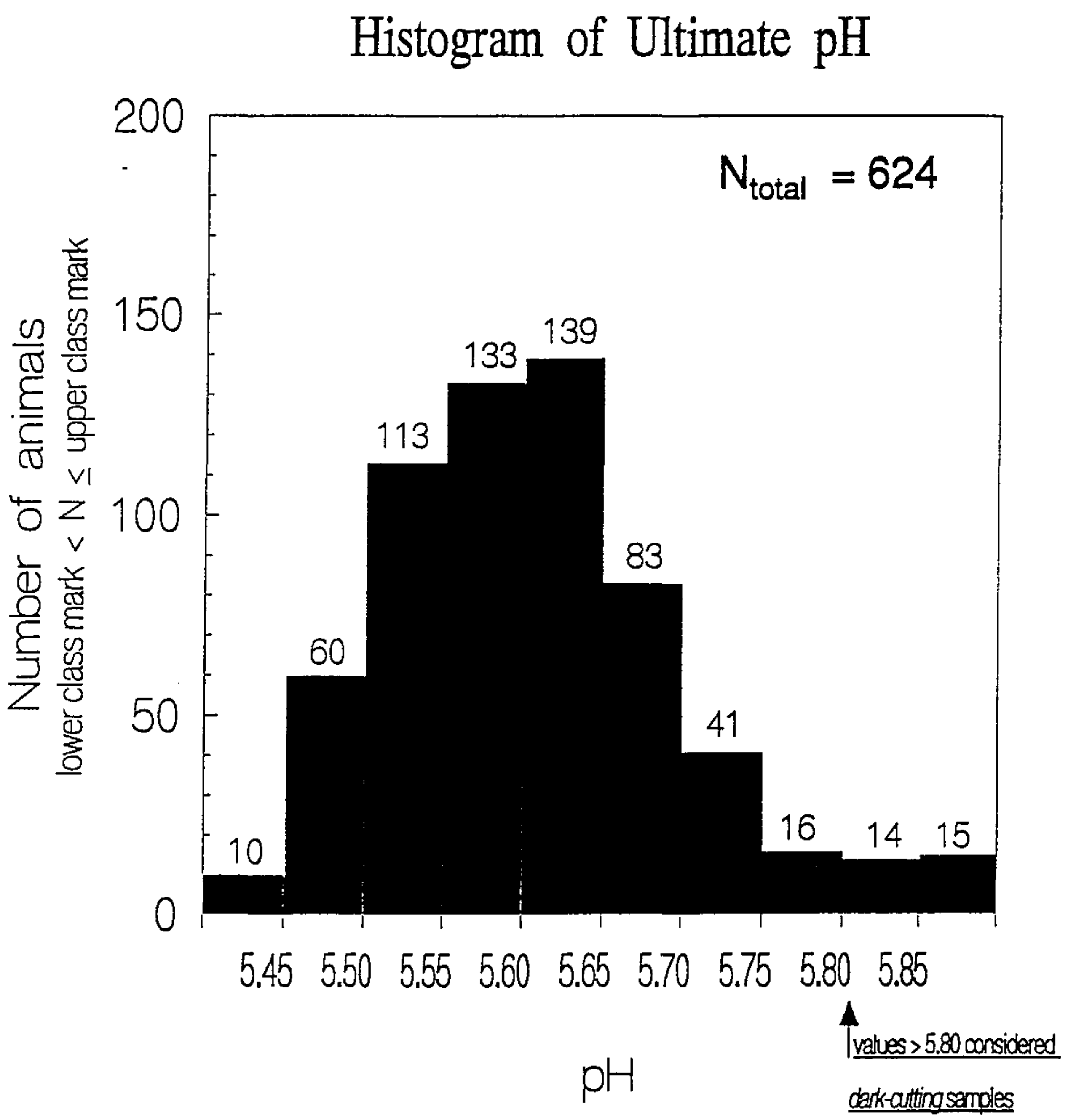

Figure 8 Histogram showing ultimate pH values measured in *Longissimus dorsi* steaks

2.3.6 Meat colour

Meat colour lightness ('L' value) means shown in Table 21, indicate that overall meat colour was darker than average.

Table 21 Effect of postweaning nutrition on *Longissimus dorsi* surface muscle colour (Hunter 'L' value)

Main effect means within a row or within a column followed by the same letter do not differ significantly (P>0.05). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT
	185	260	320	Avge. LSD (P=0.05) =2.18
LMH	34.00	35.69	34.65	34.78
MMM	33.04	34.03	32.44	33.17
HHH	34.13	35.24	33.88	34.42
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =2.18	33.72	34.99	33.66	
H^+ NUTRITIONAL REGIME	31.18	37.76	38.36	
	Avge. SEM = ±0.54			

Urban Australians consider beef LD steaks with an 'L' value of about 39. to be of 'average' lightness and those with 'L' values of about 35 to be 'slightly dark' (Shorthose and Harris, unpublished data).

The main effect of nutritional regime or target carcase weight had no influence on surface muscle colour, nor was there any apparent trend due to these main effects.

A number of factors influence meat colour. Pigment (myoglobin) concentration increases with animal age. Meat colour is expected to get darker with animal age, however, meat colour is also influenced by cooling rate of muscles post mortem (slower cooling results in lighter coloured meat). As older animals usually have heavier and fatter carcases, their muscles cool more slowly and this effect would be expected to counter increases in darkness due to increasing myoglobin concentration, associated with animal age. The net influence of these two factors on LD meat colour of the fast chilled carcases in this study is shown in Figure 9. This figure based on 12 points (average of the two drafts, plus the H^+ unreplicated means), shows a non-significant quadratic trend ($P > 0.05$),however mean colour ('L' value) of the young animals was similar to the meat colour ('L' value) of the older animals. It was considered that the LD muscles of the animals of intermediate ages cooled more slowly than those of the young animals and that, although the old, heavy, animals cooled the slowest, this influence was more than compensated for by an age related increase in myoglobin concentration.

Within carcase weight groups, the meat of the younger animals had the greater 'L' values. An exception was the H^+ 185 kg group. This group had a high mean ultimate pH and lower than expected 'L' values, showing the influence of ultimate pH on 'L' values.

2.3.7 Sarcomere length

Nutritional regime had no significant ($P > 0.05$) influence on LD sarcomere length, however there was a marginal trend of increasing sarcomere length with improved nutrition (Table 22).

Samples from the 320 kg target carcase weight had significantly longer ($P < 0.05$) sarcomeres than samples from the 185 kg target carcase weight groups. The samples from the 260 kg target carcase weight group were no different to the samples from the 185 kg or 320 kg targets. There was indication of a similar trend of increasing sarcomere length with increased target carcase weight in the H^+ nutritional regime.

The chilling regime used was by industry standards quite fast. It was equivalent to that prescribed in AQIS meat order 250 (Anon, 1985). Sarcomere lengths reflect chilling regimes and indicate the effectiveness of electrical stimulation.

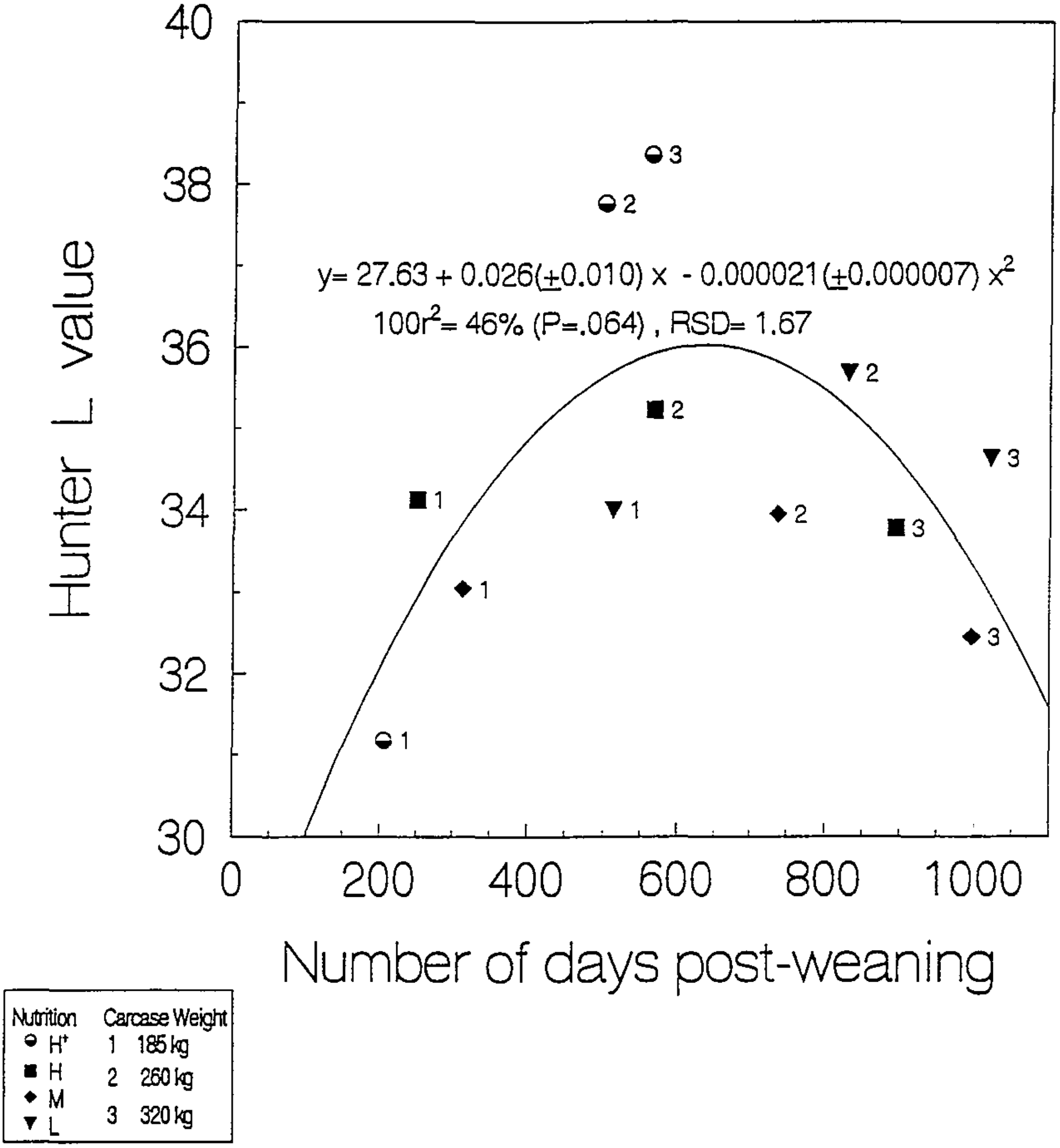

Figure 9 Quadratic regression between days post weaning and Hunter 'L' value of *Longissimus dorsi* steaks (based on 12 points, being the average of the two year drafts plus the unreplicated H^+ groups)

Table 22 Effect of postweaning nutrition on *Longissimus dorsi* sarcomere length (μm)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.037
	185	**260**	**320**	
LMH	1.687	1.742	1.817	1.749
MMM	1.723	1.765	1.785	1.758
HHH	1.757	1.762	1.767	1.762
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.037	1.722^{b}	1.757^{ab}	1.790^{a}	
H^{+} NUTRITIONAL REGIME	1.699	1.768	1.814	
		Avge. SEM = ±0.019		

Figure 10 shows the distribution of sarcomere length values of all individual animals recorded in the project. The majority of LD samples (71.5%) in this project had sarcomere lengths less than 1.80μm which suggests that most LD samples had shortened somewhat, due to the chilling regime, and that the electrical stimulation was not completely effective in minimising this shortening. Sarcomere lengths are influenced by chilling conditions (of individual muscles), the effectiveness of electrical stimulation and ultimate pH. The LD muscle is a superficial muscle in the bovine carcase and is free to shorten and, therefore, more affected by chilling regimes than many other muscles in the carcase.

Only 7% of LD samples were considered to have desirable, long, sarcomere lengths ($\geq$1.90 μm).

In muscles of unstimulated carcases, LD samples from heavier and fatter animals are expected to have longer sarcomeres.

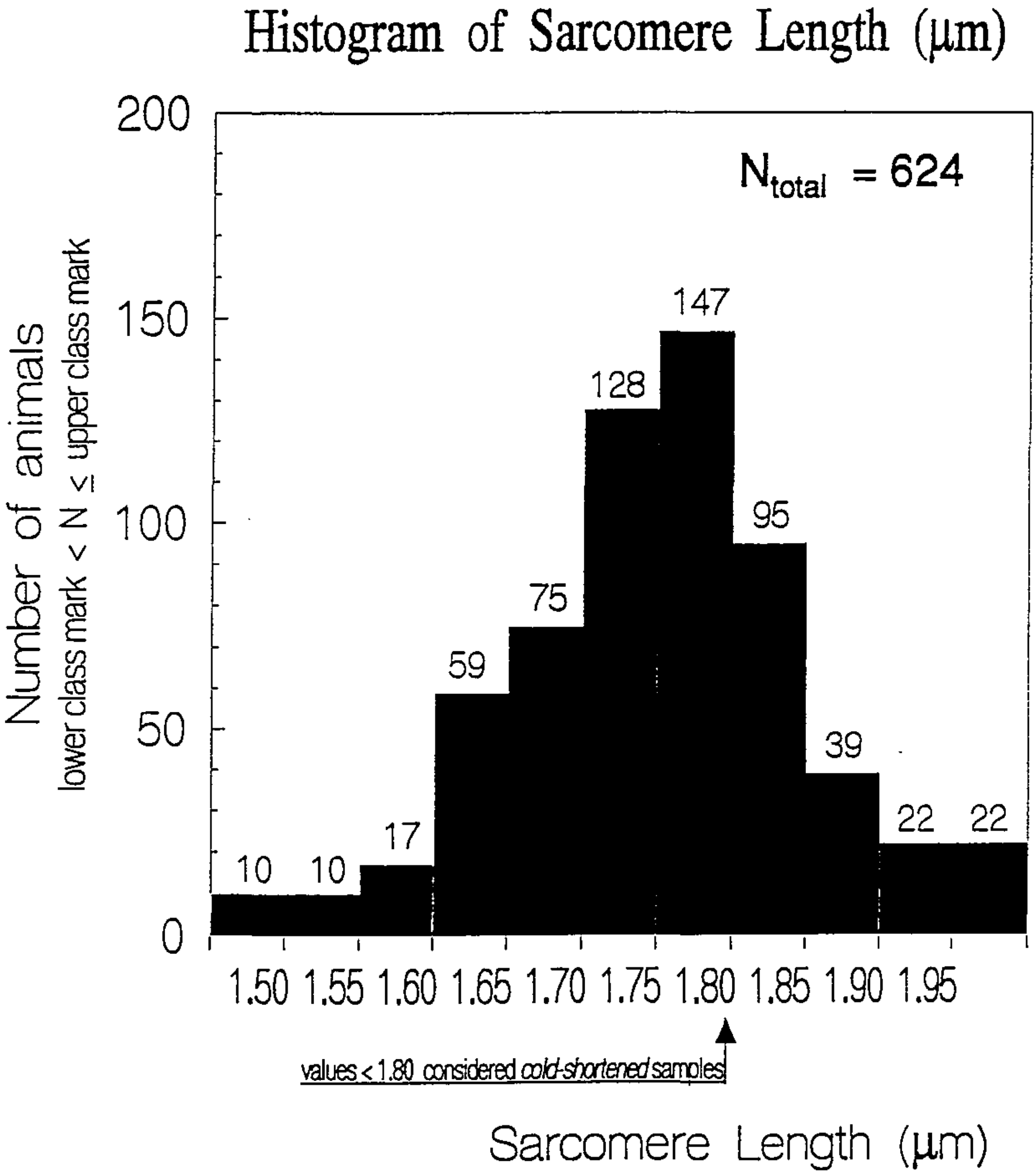

Figure 10 Histogram showing sarcomere length values measured in *Longissimus dorsi* steaks

LD samples from 320 kg carcases were longer than those at 185 kg.

The linear coefficient of determination between carcase weight and sarcomere length was $100r^2=47\%$ ($P<0.01$). The linear relationship between rump fat depth and sarcomere length shown in Figure 6 is positive ($100r^2=54\%$, $P<0.01$),while the linear relationship between LD fat content and sarcomere length shown in Figure 11 is also positive ($100r^2=50\%$, $P<0.01$). From the data there was a tendency for heavier or fatter carcases to have longer sarcomeres. These relationships indicated that cooling rate influenced sarcomere length. When stimulation is effective, cooling rates do not influence sarcomere length, unlike ultimate pH which is expected to effect LD sarcomere length (Shorthose and Harris, 1991).

2.3.8 Objective tenderness measurements

The Warner Bratzler (WB) initial yield values (Table 23) reflect variations in the myofibrillar contribution to meat toughness.

Table 23 Effect of postweaning nutrition on *Longissimus dorsi* Warner Bratzler initial yield values (kg)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.80
	185	260	320	
LMH	6.65	5.68	5.59	5.97
MMM	5.38	5.34	4.93	5.21
HHH	5.37	5.47	6.14	5.66
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.80	5.80	5.50	5.55	
H^+ NUTRITIONAL REGIME	6.54	4.71	4.71	
		Avge. SEM = ±0.32		

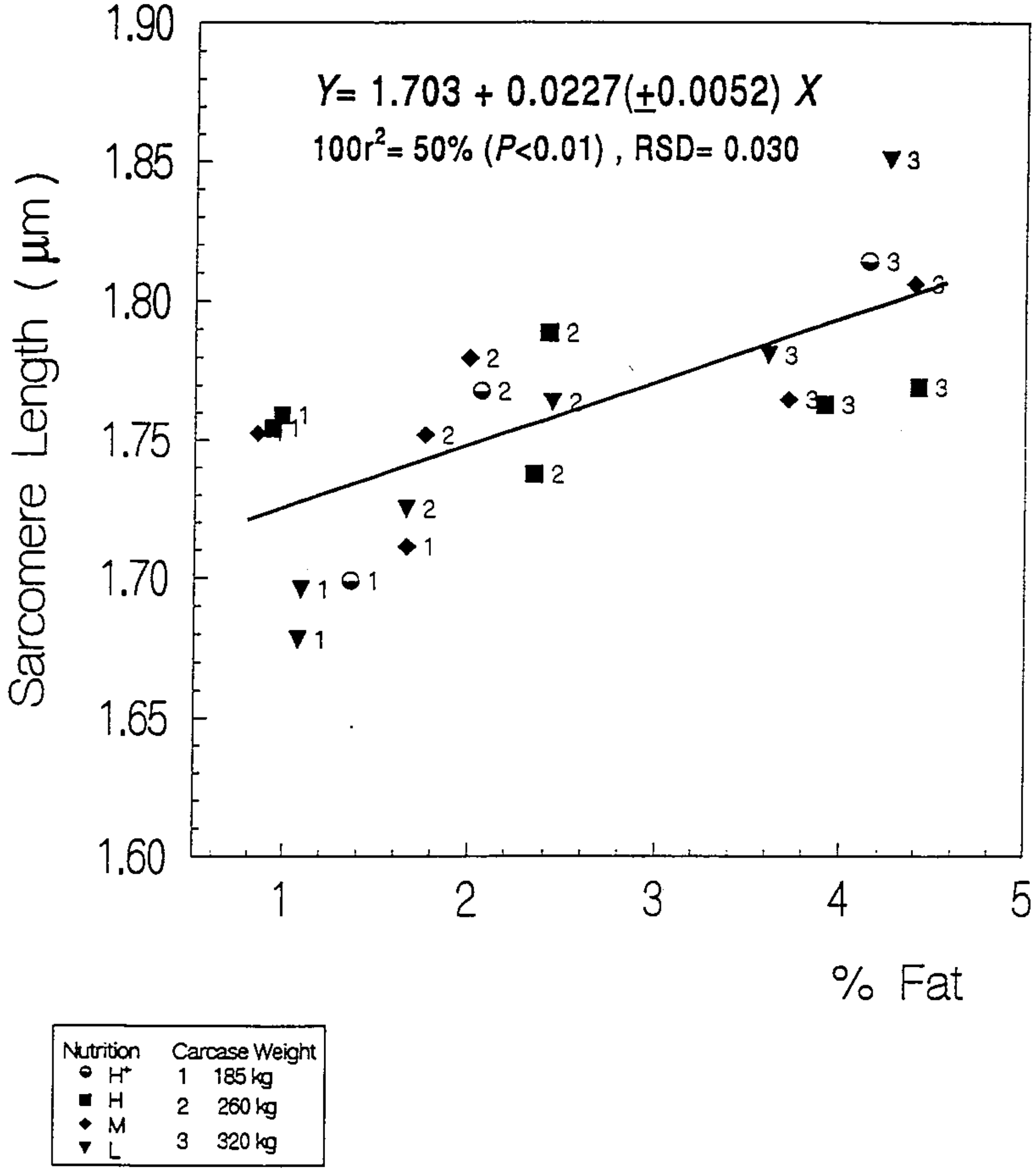

Figure 11 Linear regression between fat content (% fat) and sarcomere length of *Longissimus dorsi* steaks

In this project, on average, all groups had 'tender' (4 kg) to 'acceptably tender' (8 kg) WB initial yield values.

The main effects of nutritional regime and target carcase weight were both non-significant for WB initial yield values ($P>0.05$).

The descriptive data for the H^+ nutritional regime indicates lower values for the 260 kg and 320 kg target carcase weight groups.

The histogram of Figure 12, shows the distribution of WB initial yield values and indicates approximate normality for this attribute but with some positive skewness. Figure 12 highlights the 'average acceptable tenderness' nature of the LD samples in this project in respect to myofibrillar meat toughness. There is considerable variation associated with this attribute, with a coefficient of variation of 31.2%. The 90th percentile was recorded at a WB initial yield value of 7.88 kg.

In the population, 9.3% had LD samples considered tough with WB initial yield values greater than 8.00 kg, while on the other hand, 13.1% of LD samples were considered tender, as WB initial yield values were less than 4.00 kg.

Initial yield values are expected to be influenced by sarcomere length and ultimate pH; the effectiveness of electrical stimulation decreases as ultimate pH decreases from 5.5 towards 6.0 and has no effect once ultimate pH exceeds 6.0. The attributes, sarcomere length and initial yield were correlated ($100r^2=38\%$, $P<0.01$) as shown in Figure 13. The linear coefficient of determination between ultimate pH and initial yield was $100r^2=26\%$ ($P<0.05$). Within dentition groups, ultimate pH accounts for up to 43% of the variation in initial yield or peak force values, but accounts for only a very small amount of the variation, about 8%, of Instron compression values.

Based on overseas reports, marbling and fat content of the LD influences myofibrillar tenderness. In our study, there was no significant relationship (based on cell means) between either of these attributes and WB initial yield values ($100r^2=6\%$, $100r^2=9\%$, both n.s.) suggesting that marbling or fat content had little influence on initial yield.

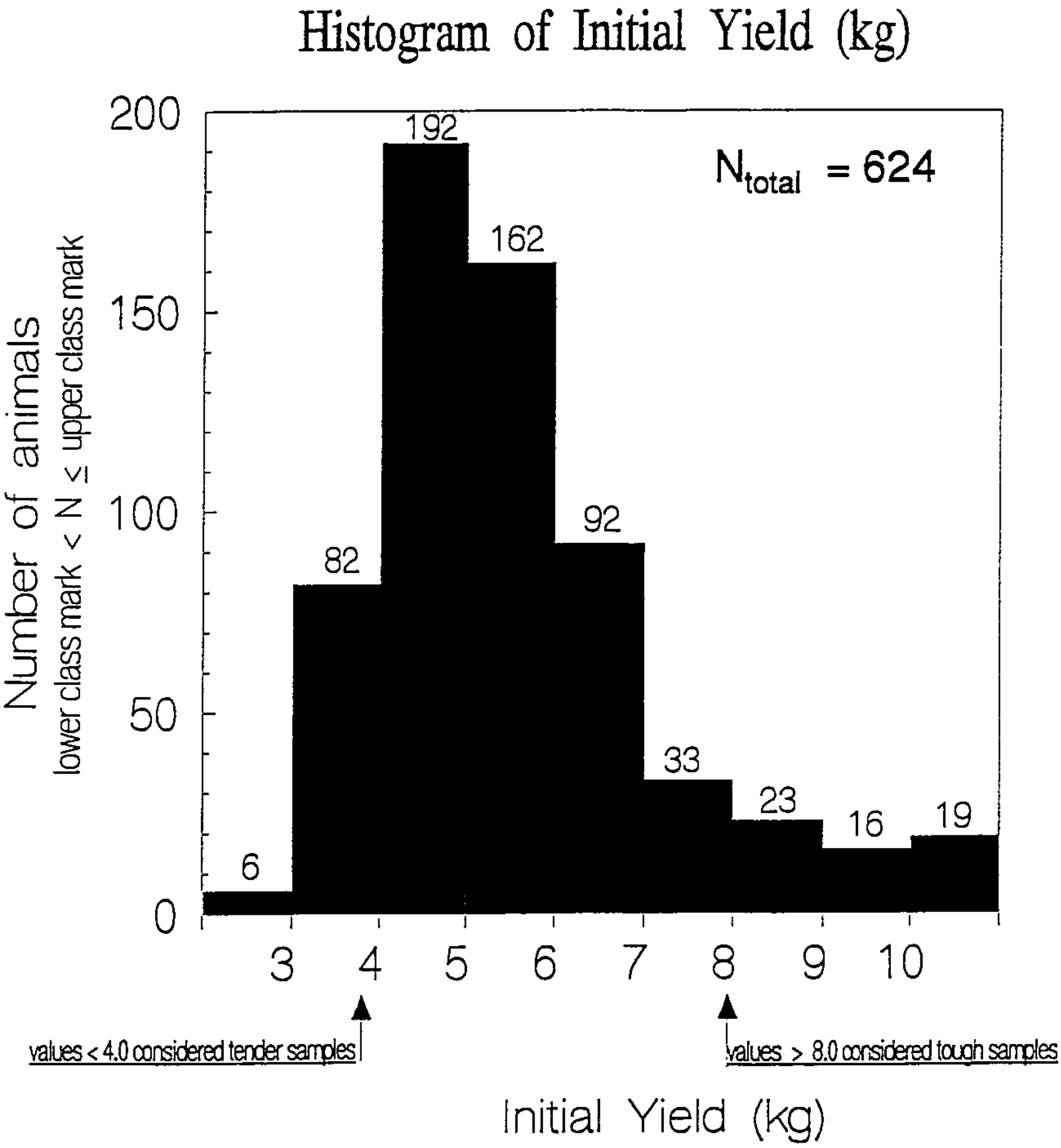

Figure 12 Histogram showing initial yield values measured in *Longissimus dorsi* steaks

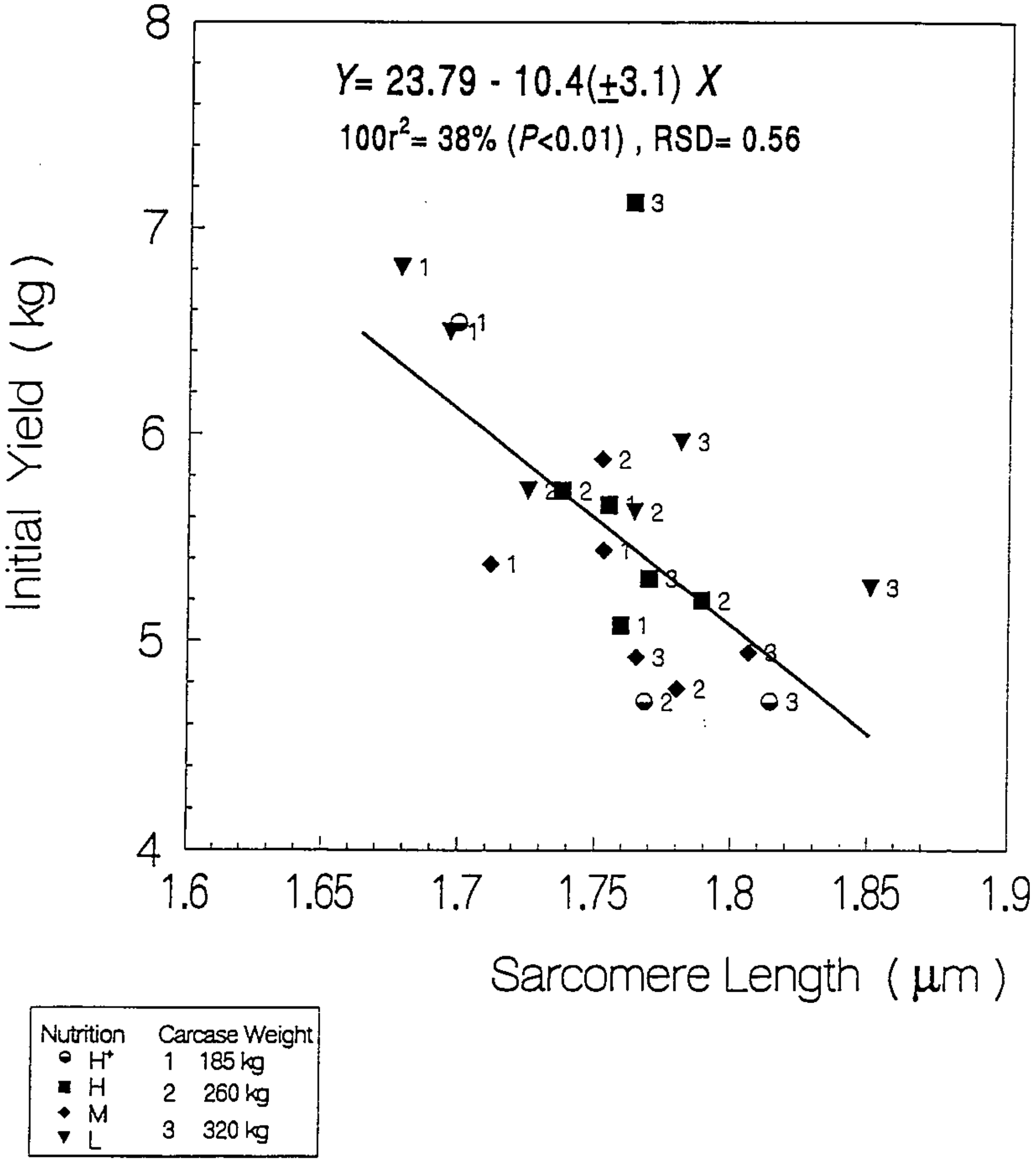

Figure 13 Linear regression between sarcomere length and initial yield of *Longissimus dorsi* steaks

For peak force (Table 24) the main effects of nutritional regime and target carcase weight were non-significant ($P > 0.05$). The peak force nutritional regime main effect means, trended lower as nutrition improved, and peak force declined marginally as the target carcase weight increased. There was indication of a more marked decline in peak force with increasing target carcase weight in the H^+ nutritional regime, due in part to the higher mean ultimate pH (5.724) of the 185 kg H^+ nutritional regime group.

Table 24 Effect of postweaning nutrition on *Longissimus dorsi* Warner Bratzler peak force values (kg)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT 185	260	320	NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.81
LMH	7.43	6.26	6.16	6.62
MMM	6.30	6.28	5.49	6.02
HHH	6.04	6.03	6.57	6.22
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.81	6.59	6.19	6.07	
H^+ NUTRITIONAL REGIME	7.35	5.41	5.19	
		Avge. SEM = ±0.30		

Peak force reflects primarily myofibrillar properties but provides less of an indication of connective tissue contribution to toughness than Instron compression values. The relationship between initial yield and peak force is very strong and positive ($100r^2=94\%$, $P<0.01$)as shown in Figure 14. Initial yield values provide an excellent measure of peak force values, as expected.

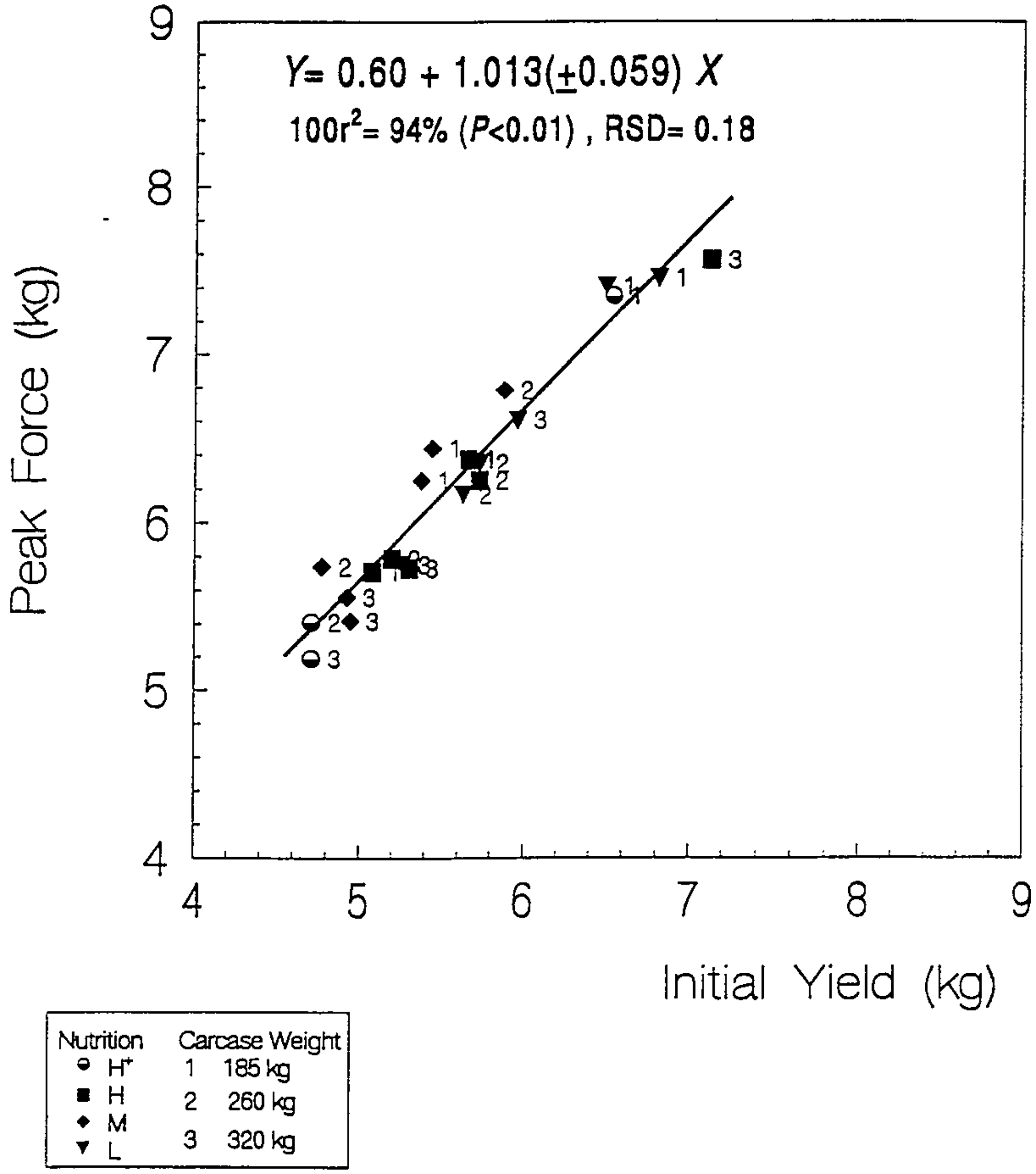

Figure 14 Linear regression between initial yield and peak force of *Longissimus dorsi* steaks

The main effects of nutritional regime and target carcase weight were both significant ($P<0.05$) for peak force minus initial yield values (Table 25). Both the LMH and HHH nutritional regimes had significantly lower ($P<0.05$) values than the MMM nutritional regime. The peak force minus initial yield means at the 320 kg target carcase weight were significantly lower ($P<0.05$) than at either the 185 kg or 260 kg targets. Values declined as the target carcase weight increased in the H^+ nutritional regime groups.

Table 25 Effect of postweaning nutrition on *Longissimus dorsi* Warner Bratzler peakforce minus initial yield values (kg)

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT 185	260	320	NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.13
LMH	0.78	0.58	0.57	0.64^c
MMM	0.92	0.94	0.56	0.81^a
HHH	0.67	0.56	0.43	0.55^b
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.13	0.79^a	0.69^a	0.52^b	
H^+ NUTRITIONAL REGIME	0.81	0.71	0.48	
	Avge. SEM = ±0.07			

Peak force minus initial yield values are considered an index of the connective tissue contribution to tenderness when muscles have not shortened below 1.9 μm. As considerable shortening occurred in the LD samples of this project it is difficult to suggest why significant differences in peak force minus initial yield values occurred.

In Tables 26 to 28, data for the WB attributes of pressure heat treated samples are shown and are discussed collectively. The technique of pressure heat treatment is designed to minimise the myofibrillar contribution to toughness and maximise the connective tissue contribution.

Table 26 **Effect of postweaning nutrition on *Longissimus dorsi* pressure heat Warner Bratzler initial yield values (kg)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT
	185	**260**	**320**	Avge. LSD (P=0.05) =0.145
LMH	2.016	1.855	1.839	1.903
MMM	1.914	1.950	1.823	1.896
HHH	2.063	2.159	1.755	1.992
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.145	1.998^{a}	1.988^{a}	1.806^{b}	
H^{+} NUTRITIONAL REGIME	2.007	1.806	1.695	
	Avge. SEM = ±0.056			

The nutritional regime main effect was not significant ($P>0.05$) for either the pressure heat WB initial yield (Table 26), peak force (Table 27) or peak force minus initial yield (Table 28) values nor was there any trend in these values. Samples from the 320 kg target carcase weight had significantly lower ($P<0.05$) pressure heat WB initial yield values than samples from the 185 kg or 260 kg targets. Target carcase weight had no influence on either the pressure heat WB peak force or peak force minus initial yield values. Overall, samples from the 320 kg target weight group had lower values for these three attributes, with the same trend being indicated in the H^{+} nutritional regime.

Table 27 **Effect of postweaning nutrition on *Longissimus dorsi* pressure heat Warner Bratzler peak force values (kg)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT 185	 260	 320	NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.362
LMH	2.965	2.863	2.949	2.926
MMM	3.192	3.112	2.871	3.058
HHH	3.069	3.189	2.727	2.995
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.362	3.075	3.055	2.849	
H^+ NUTRITIONAL REGIME	3.201	2.473	2.422	
	Avge. SEM = ±0.074			

Of these pressure heat attributes, peak force is considered the least subjective and most repeatable in terms of measuring force deformation curves. The pressure heat peak force means (Table 27) indicated a non-significant trend of lower values at the heavier target carcase weight. A similar trend was indicated in the H^+ nutritional regime. This is not an expected trait as carcase weight generally increases with age and older animals would be expected to have higher pressure heat peak force values, reflecting a greater connective tissue contribution. The LD samples in this project had shortened muscle fibres, as discussed previously. When muscle shortening is minimised by tender stretching, or effective electrical stimulation, the connective tissue contribution to the toughness of the LD muscle does not increase as much with age as it does in other muscles, particularly the *Semimembranosus*.

Table 28 **Effect of postweaning nutrition on *Longissimus dorsi* pressure heat Warner Bratzler peak force minus initial yield values (kg)**

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.280
	185	260	320	
LMH	0.950	1.007	1.110	1.022
MMM	1.277	1.162	1.048	1.162
HHH	1.006	1.030	0.971	1.002
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.280	1.078	1.066	1.043	
H^+ NUTRITIONAL REGIME	1.19	0.67	0.73	
		Avge. SEM = ±0.05		

Nutritional regime and target carcase weight main effects were non-significant ($P>0.05$) for Instron compression values in this project (Table 29). There was a trend of declining values with improving nutrition, but no consistent trend for target carcase weight.

There was no consistent trend with target carcase weight in the descriptive data of the H^+ nutritional regime; however, it is noted that the H^+ mean values for this attribute are lower than the mean values from the main analysis.

Table 29 **Effect of postweaning nutrition on *Longissimus dorsi* Instron compression values (kg)**

Main effect means within a row or within a column followed by the same letter do not differ significantly (P>0.05). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.20
	185	**260**	**320**	
LMH	2.00	2.09	2.03	2.04
MMM	2.04	2.07	1.92	2.01
HHH	1.88	1.98	1.99	1.95
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.20	1.97	2.05	1.98	
H^+ NUTRITIONAL REGIME	1.73	1.81	1.75	
		Avge. SEM = ±0.04		

Instron compression values are considered the most useful single variable for indicating toughness. Means for this attribute are high (greater than 2 kg) in many groups. Values of greater ≥2 kg are considered to represent tough meat.

The histogram for Instron compression values is shown in Figure 15. Instron compression values exhibit normality and Figure 15 clearly indicates the number of LD samples in this project with values greater than 2 kg.

In the data, the 50th percentile falls at an Instron compression value of 1.97 kg, indicating that nearly half of the LD samples were considered tough. The high incidence of tough samples is attributed to muscle shortening and the connective tissue contribution, not the connective tissue contribution alone.

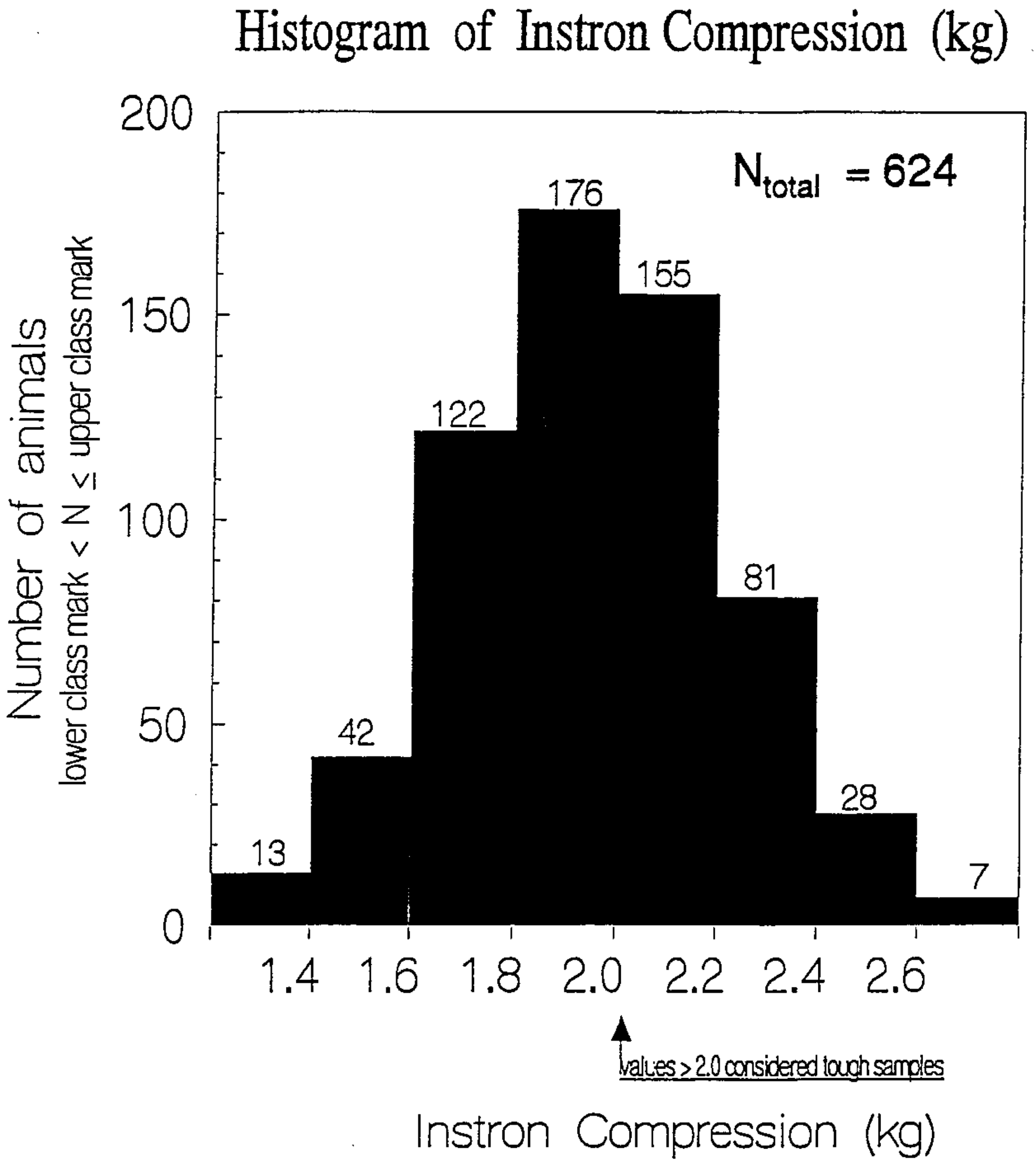

Figure 15 Histogram showing Instron compression values measured in *Longissimus dorsi* steaks

The coefficient of variation for this attribute was 12.4%, far less than other meat quality attributes. Warner Bratzler measurements are influenced little by connective tissue, while the Instron compression value of LD samples is of greatest benefit in indicating the connective tissue contribution to toughness when muscle shortening is minimal.

The frequency of samples recording Instron compression values greater than 2 kg for target carcase weight, nutritional regime and dentition classes are shown in Tables 30 and 31. There was no consistent trend in the frequency of tough samples across carcase weights (Table 30). In draft 2 there was a tendency towards less prevalence of samples with values greater than 2 kg as the nutritional regime was improved, with the lowest incidence recorded in the H$^+$ nutritional regime.

Table 30 **Frequency (%) of Instron compression values recorded strictly greater than 2 kg by target carcase weight and nutritional regime**

Nutritional Regime		Target Carcase Weight							
		185		260		320		Overall	
LMH	Draft 1	31		47		37		38	(36/94)[1]
	Draft 2	66		81		59		68	(58/85)
MMM	Draft 1	69		59		17		49	(46/94)
	Draft 2	25		70		68		60	(46/77)
HHH	Draft 1	50		30		48		43	(38/89)
	Draft 2	6		63		47		39	(37/96)
Overall	Draft 1	50	(48/96)	46	(43/94)	33	(29/87)	43	(120/277)
	Draft 2	34	(27/80)	70	(62/88)	58	(52/90)	55	(141/258)
H$^+$	Draft 2	9	(3/32)	11	(3/28)	14	(4/29)	11	(10/89)

[1] Cell number/number in draft (by target carcase weight and growth rate pattern).

There was no clear trend of a change in the frequency of Instron compression values greater than 2 kg (Table 31) due to dentition (number of permanent teeth) in draft 1 while the incidence tended to increase as the number of permanent teeth increased in draft 2. Dentition had little influence on the incidence of high values in the H$^+$

nutritional regime. The relatively young age (0, 2 and 4 permanent teeth) of the H^- groups at turnoff is reinforced in the data of Table 31.

Table 31 **Frequency (%) of Instron compression values recorded strictly greater than 2 kg for each dentition class**

	No. Permanent Teeth					
	0	2	4	6	8	Overall
Draft 1	50	31	51	41	33	43 (120/277)[1]
Draft 2	14	65	73	60	61	55 (141/258)
Draft 2 - H^-	9	13	14	-	-	11 (10/89)

[1] cell number/total number in draft.

The relationship between overall average daily gain and LD Instron compression values based on cell means is shown in Figure 16. The relationship although negative and weak ($100r^2=37\%$, $P<0.01$) indicates that Instron compression values may decline with increasing ADG (decreasing age) as expected. The relationship was not as strong as expected from the results of Shorthose and Harris (1990). These authors indicate that if cold or myofibrillar shortening is avoided then Instron compression values increase with age.

The lower than expected strength of the correlation between ADG/age and LD Instron compression values in this project is due to the influence of muscle shortening, the low connective tissue contribution to toughness in the LD, and that this connective tissue contribution increases more slowly than in other muscles. From our data we are unable to confirm that LD muscle toughness due to the contribution of connective tissue is much less in younger animals.

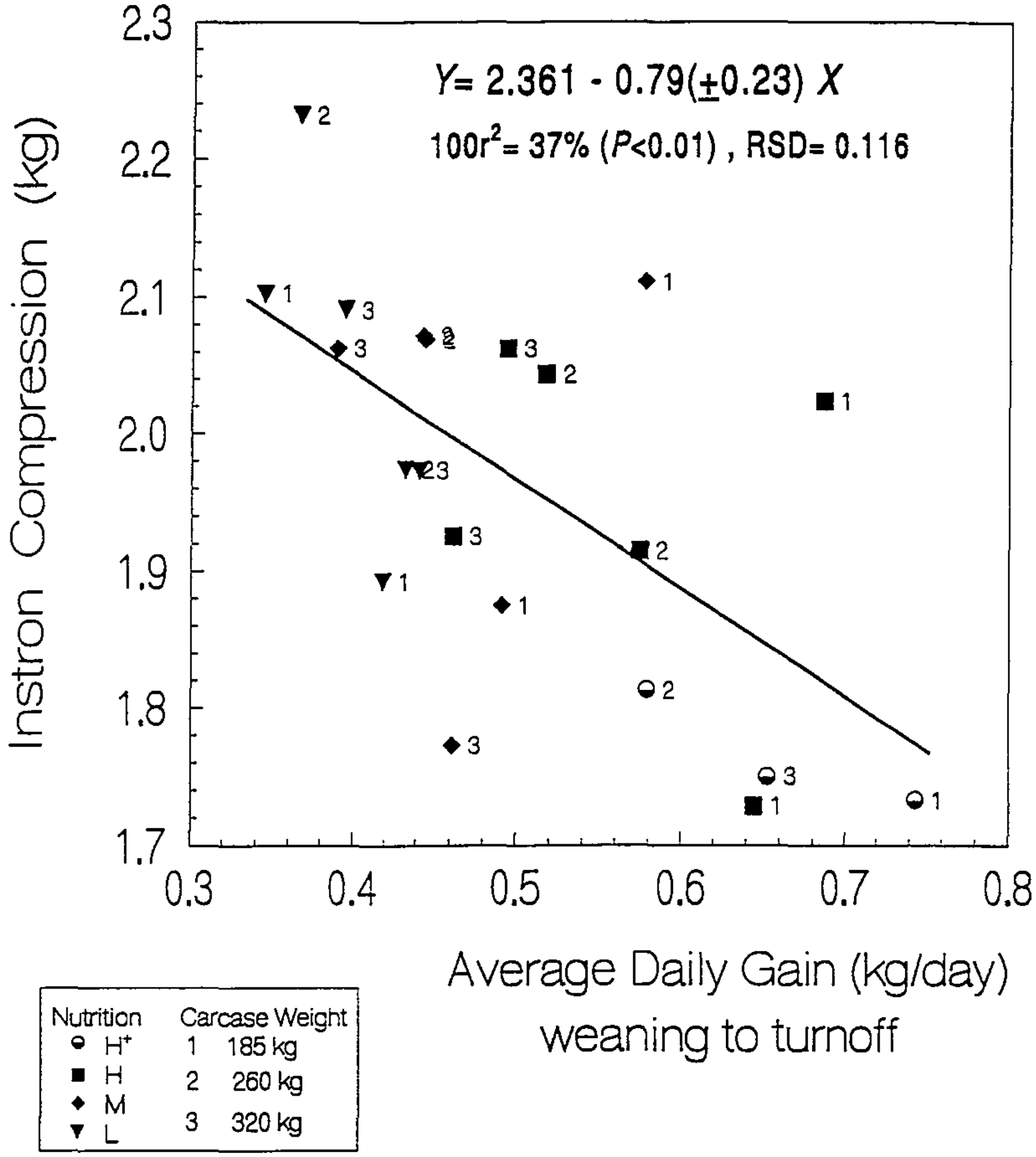

Figure 16 Linear regression between the overall growth rate of steers and the Instron compression values of *Longissimus dorsi* steaks

2.3.9 Sensory evaluation attributes

Sensory (subjective) evaluation data is shown in Tables 32 to 36. These data are based on a subset of LD samples, with the actual numbers evaluated, shown in appendix VI. Nutritional regime and target carcase weight had no significant influence on drip loss (Table 32). The covariate, number of days frozen was significant ($P<0.05$) for this attribute with drip loss increasing 1% for every 58 days of frozen storage. The data shown in Table 32 has been adjusted for the covariate. Some samples were frozen up to 200 days before evaluation. The descriptive data of the H^- nutritional regime indicates a greater drip loss was recorded at the 185 kg target carcase weight compared to the other targets.

Table 32 Effect of postweaning nutrition on *Longissimus dorsi* drip loss due to thawing (%)[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=1.2$
	185	260	320	
LMH	3.3	4.0	2.7	3.3
MMM	3.4	2.6	3.7	3.2
HHH	3.9	3.0	3.1	3.3
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=1.4$	3.5	3.2	3.2	
H^+ NUTRITIONAL REGIME	5.7	3.0	3.6	
	Avge. SEM = ±0.96			

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[1] The covariate, number of days frozen was significant ($P<0.05$) for means other than H^+.

For sample juiciness the main effects of nutritional regime and target carcase weight (Table 33) were not significant (P>0.05).

Table 33 Effect of postweaning nutrition on *Longissimus dorsi* juiciness values[1&2]

Main effect means within a row or within a column followed by the same letter do not differ significantly (P>0.05). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	**TARGET CARCASE WEIGHT**			**NUTRITIONAL REGIME MAIN EFFECT** Avge. LSD (P=0.05) =0.28
	185	**260**	**320**	
LMH	5.09	5.29	5.46	5.28
MMM	5.30	5.62	5.19	5.37
HHH	4.69	5.14	5.46	5.10
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.30	5.03	5.35	5.37	
H^+ NUTRITIONAL REGIME	4.93	5.55	5.61	
		Avge. SEM = ±0.17		

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[1] Score - 1 (extremely dry) to 8 (extremely juicy).

[2] The covariate, number of days frozen was significant (P<0.05) for means other than H^+.

There was no apparent trend in values for nutritional regime, while the data shows a marginal increase in values as the target carcase weight increased. A similar trend was recorded across target carcase weights for the descriptive data of the H^+ nutritional regime. The covariate, number of days frozen was significant for juiciness (P<0.05). The juiciness data indicates that most groups had above average values meaning that the LD samples were considered moderately juicy.

The nutritional regime main effect on sensory evaluation 'beef' flavour intensity scores (Table 34) was not significant (P>0.05).

Table 34 Effect of postweaning nutrition on *Longissimus dorsi* 'beef' flavour intensity score[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD ($P=0.05$) $=0.17$
	185	260	320	
LMH	5.04	5.23	5.48	5.25
MMM	5.24	5.26	5.40	5.30
HHH	5.22	5.39	5.36	5.32
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD ($P=0.05$) $=0.17$	5.17^{a}	5.29^{ab}	5.41^{b}	
H^{+} NUTRITIONAL REGIME	5.11	5.52	5.28	
	Avge. SEM = ±0.11			

[1] Flavour score - 1 (very weak) to 7 (very strong).

The 320 kg target carcase weight group had a significantly greater ($P < 0.05$) flavour score than the 185 kg target. There was no indication of any trend in flavour scores across the target carcase weights of the H^{+} nutritional regime.

Flavour scores suggested that the LD samples had an above average 'beef' flavour (mean scores approaching 7 on the 1-7 scale), regardless of whether the beef was from *grassfed* (LMH, MMM or HHH nutritional regimes) or *grainfed* animals (H^{+} nutritional regime). In addition, there was no apparent difference in flavour score between the *grassfed* or *grainfed* groups.

Flavour is one attribute that is considered to be influenced by marbling (fat content). Linear coefficients of determination based on cell means were $100r^2=44\%$ ($P<0.01$)

between marbling and flavour, and $100r^2=37\%$ ($P<0.05$)between fat content and flavour suggesting fat content influenced flavour.

Sensory evaluation tenderness scores of Table 35 indicate that, overall, LD samples were of average tenderness. These data confirm the results of the objective Warner Bratzler and Instron compression measurements taken. Neither the nutritional regime nor target carcase weight main effects were significant ($P>0.05$) for tenderness score.

Table 35 Effect of postweaning nutrition on *Longissimus dorsi* tenderness score

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P>0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.48
	185	260	320	
LMH	4.29	4.66	4.74	4.56
MMM	4.91	4.63	5.00	4.85
HHH	4.37	4.97	4.70	4.68
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.49	4.52	4.75	4.81	
H^+ NUTRITIONAL REGIME	4.98	4.94	5.67	
	Avge. SEM = ±0.39			

[1] Tenderness score - 1 (very tough) to 8 (very tender).

The H^+ nutritional regime descriptive data indicates little difference in tenderness score between the 185 and 260 kg target carcase weights, while the tenderness score of the 320 kg target carcase weight is improved compared to the lighter targets.

Although both objective measurements and taste panel scores indicated that samples from all treatments were of average tenderness, correlations between WB initial yield, WB peak force and instron compression values and taste panel tenderness scores were not significant. This was surprising, even though it was anticipated that the correlations between panel scores and individual objective measurements would not be high.

In overseas studies, considerable emphasis has been placed on marbling and sensory evaluation tenderness score based on the LD muscle.

There was little relationship between marbling and sensory evaluation tenderness score based on cell means, as the linear coefficient of determination was $100r^2=9\%$ (n.s.). Fat content of the LD had a better relationship with tenderness score, with a linear coefficient of determination based on cell means of $100r^2=32\%$ ($P<0.05$).

In this project, the marbling score/fat content of LD steaks from *Bos indicus* cross animals appears to be unrelated to the tenderness of these steaks. The relationship between protein content and tenderness score was not correlated with a linear coefficient of determination based on cell means of $100r^2=8\%$ (n.s.).

In this project, as with many others, it was not possible to measure the direct effect of marbling on meat tenderness, over and above any indirect influence due to the covariation of marbling, carcase fatness, carcase weight and carcase cooling rate. The fat component of marbling did not contribute to perceived tenderness *per se*. Increased marbling was associated with increased fat levels at heavier carcase weights. This would influence cooling rates of LD muscles producing the differences in sarcomere lengths and tenderness.

Previous research by one of the authors has shown that relationships between high marbling scores and improved tenderness are now considered redundant if carcases are 'tenderstretched' or effectively electrically stimulated to prevent muscle shortening. Present results indicate that this is also the case even when carcases are less than effectively electrically stimulated.

An overall sensory evaluation quality rating of the LD steaks is shown in Table 36.

Table 36 Effect of postweaning nutrition on *Longissimus dorsi* quality rating[1]

Main effect means within a row or within a column followed by the same letter do not differ significantly ($P > 0.05$). Absence of lettering indicates no significant differences. LSD values apply only to respective main effect means.

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT			NUTRITIONAL REGIME MAIN EFFECT Avge. LSD (P=0.05) =0.29
	185	**260**	**320**	
LMH	4.65	4.96	5.27	4.96
MMM	5.02	4.96	5.22	5.07
HHH	4.53	5.15	5.09	4.92
TARGET CARCASE WEIGHT MAIN EFFECT Avge. LSD (P=0.05) =0.29	4.73^{a}	5.02^{ab}	5.19^{b}	
H^{+} NUTRITIONAL REGIME	4.93	5.27	5.60	
		Avge. SEM = ±0.20		

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[1] Quality score - subjective rating - 1 (unacceptable) to 8 (acceptable).

The nutritional regime main effect on sensory evaluation quality ratings was non-significant ($P > 0.05$). However, the quality rating at the 320 kg target carcase weight was significantly better ($P < 0.05$) than at the 185 kg target.

A trend of increasing score with target carcase weight was apparent for the descriptive data of the H^{+} nutritional regime.

Overall, the LD samples in this project were rated subjectively as slightly above average for quality. Higher quality ratings would be expected if muscle shortening had not contributed to the extent recorded.

2.4 Economic consideration

In this project, the incorporation in draft 2 of a H^- nutritional regime, based on grain feeding produced higher growth rates and reduced the turnoff age compared to the *grassfed* groups. At the 320 kg target carcase weight, turnoff time was reduced by approximately one year (357 days) compared to the HHH 320 kg turnoff group.

Although not statistically tested, and despite the degree of muscle shortening recorded in this project, the H^- groups had lower Instron compression values than the *grassfed* groups. The H^+ groups also recorded much lower incidences of high Instron compression values compared to the *grassfed* groups. Over all data the relationship between high growth rate and low Instron compression values could not be confirmed. However, the influence on Instron compression values of the higher growth rates (or younger ages) of the H^+ groups was apparent. Recommendations to industry based on other studies include an optimal turnoff age of 30 months regardless of market in order to achieve a higher quality meat product. In this project, the mean age of the oldest H^- turnoff group (the 320 kg target) approximated 27 months. Through the use of a grain feeding regime in this project a significant reduction in turnoff age was achieved. However, this was achieved at considerable cost as shown in Table 37.

Table 37 Economic analysis of grain supplementation to meet target carcase weights (analysis based on gross margin and accounts for capital costs, eg. feeders, silos, etc.)

Target carcase weight	No. feeding days	Grain ration cost (\$/head)	Total variable costs (\$/head)	Gross income (\$/head)	Gross margin (\$/head)	Breakeven sale price[1] (\$/kg dw[2])
185 kg - Australian domestic	205	143	453	355	-98	2.58
260 kg - US primal	500	304	620	562	-57	2.48
320 kg - Japanese						
1. Initial paddock phase up to 450 kg LW	418	264	579	505	-74	2.53
2. Feedlot phase until turnoff	145	329	914	695	-219	2.88

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[1] Includes interest charges.

[2] Dressed weight basis.

The high cost, unsatisfactory gross margin charges and high breakeven sale prices associated with the grain supplementation regime used in this project are apparent.

The 'whole of life' grain feeding to produce steers for the Japanese market by approximately 27 months of age was uneconomical in this project.

If the steers sold at 320 kg carcase weight for the Japanese market, could have been sold earlier as planned after 100 days in the feedlot, instead of 145 days, the change in gross margin would be -$118.32/head with a breakeven sale price of $2.57/kg dw (includes interest). The greatest economic loss associated with this nutritional strategy was turnoff at 320 kg carcase weight.

If beef producers are to turnoff animals by 30 months of age, and if market weights cannot be achieved from grazing alone then other inputs are going to be required, but these must be coupled with greater financial rewards for their product. The grain feeding nutritional strategy used in this project was uneconomic based on prices received. It appears from this project and other projects carried out in similar environments that high cost inputs are required to significantly reduce turnoff age to 30 months and achieve heavyweight turnoff. Producers will need to consider the possibility of unfavourable economic outcomes in adopting current grain feeding practices to achieve target carcase weights or certain market specifications.

3. CONCLUSIONS

The growth rates required to achieve a younger turnoff of pasture fed animals at c. 30 months of age, and at preferred carcase weights, are on average greater than those normally experienced in northern Australia. Growth rates are on 'average', sufficient to produce *grassfed* animals suitable for the Korean market (260 kg carcases) at three years of age, however, the Koreans are now looking towards purchasing beef from younger animals.

Pre-slaughter stress (as indicated by increasing ultimate pH) can result in darker and tougher *Longissimus dorsi* loin steaks. Pre-slaughter stress was associated with combinations of climatic factors, particularly high ambient temperature, management of animals prior to slaughter, and increased holding times at meatworks prior to slaughter.

The colour lightness of *Longissimus dorsi* steaks from animals at the same carcase weight was influenced by an interaction between age of the animal at slaughter (affected by plane of nutrition) and carcase weight.

There was no difference in *Longissimus dorsi* steak juiciness, beef flavour or tenderness over a wide range of animal ages and carcase weights. The postweaning nutritional regime had no effect on juiciness or tenderness at any of the target carcase weights, while beef flavour was enhanced at heavier carcase weights.

The influence of pre-slaughter stress and the processing factors - electrical stimulation and chilling regime, are of greater importance than nutritional regime *per se* in affecting meat tenderness. These influences may override the effect of nutrition, resulting in a lack of relationship between younger turnoff and improved tenderness.

In the Brahman cross steers of this project, there was no difference at any of the target carcase weights in any of the indices of carcase fatness (subcutaneous fat cover, *Longissimus dorsi* steak marbling score or total fat content) due to the postweaning nutritional regime. For these indices of carcase fatness, ***grainfed*** carcases were no different to the ***grassfed*** carcases. These findings are contrary to the results from overseas studies. Marbling score or total fat content of *Longissimus dorsi* steaks had no influence on tenderness, but had partial influence on beef flavour.

The total fat content of the *Longissimus dorsi* steaks was low, regardless of whether the *Bos indicus* cross steers had been ***grassfed*** or ***grainfed***.

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APPENDIX II to VI

NUMBERS OF EXPERIMENTAL ANIMALS AVAILABLE FOR STATISTICAL ANALYSIS OF DATA

Appendix II Numbers of animals in each group used for the determination of means for animal productivity

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185	260	320
LMH	64	64	57
MMM	64	62	61
HHH	64	62	59
H^+ (Draft 2 only)	32	28	29

Appendix III Numbers of animals in each group used for the determination of carcase parameter means

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185	260	320
LMH	64	64	57
MMM	64	62	61
HHH	64	62	59
H^+ (Draft 2 only)	32	28	29

Appendix IV Numbers of animals in each group used for the determination of carcase composition means

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185[1]	260	320
LMH	32	64	57
MMM	32	62	61
HHH	32	62	59[2]
H^+ (Draft 2 only)	32	28	29

[1] For 185 target carcase weight, data only available from draft 2.

[2] No eye muscle area data for draft 2 of this turnoff. Based on n=27 for eye muscle area.

Appendix V Numbers of animals in each group used for the determination of product/meat quality means

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185	260	320
LMH	64	58[1]	57
MMM	48[2]	62	61
HHH	64	62	59
H^+ (Draft 2 only)	32	28	29

[1] No marbling data for draft 1.

[2] No data available for slaughter group 2 of draft 2.

Appendix VI Numbers of animals in each group used for the determination of sensory evaluation means[1]

NUTRITIONAL REGIME	TARGET CARCASE WEIGHT		
	185	260	320
LMH	16	16	16
MMM	8[2]	16	16
HHH	8[2]	16	16
H^+ (Draft 2 only)	8	8	8

[1] Actual numbers for determination of drip loss were: 16, 7, 8 for 185 kg LMH, MMM, HHH; 10, 14, 12 for 260 kg LMH, MMM, HHH and 11, 11, 11 for 320 kg LMH, MMM and HHH respectively.

[2] No data collected for draft 1.

APPENDIX VII

CLIMATE DATA

Appendix VII Climate data recorded prior to and at slaughter of experimental groups

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
1	185	LMH	19-11-1987	0	27.2	15.9	66					
			20-11-1987	0	28.0	17.2	70					
			21-11-1987	0	29.9	17.5	51					Muster slaughter groups (am). Return group 2 to holding paddock.
			22-11-1987	0	34.2	17.7	48					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			23-11-1987	0	34.0	14.4	68	0	29.6	20.2	65	Group 2 trucked to meatworks.
			24-11-1987					0	32.7	20.8	74	
			25-11-1987					0.2	33.2	24.1	14	Group 1 slaughtered (am)
			26-11-1987					0	32.7	15.6	23	Group 2 slaughtered (am). **(Pesticide residue testing).**
1	185	MMM	10-7-1987	0	21.9	9.9	69					
			11-7-1987	0	22.0	8.0	61					
			12-7-1987	0	22.2	5.6	65					Muster slaughter groups (am). Return group 2 to holding paddock.
			13-7-1987	0	22.4	4.0	49					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			14-7-1987	0	18.9	3.2	46	0	22.3	3.4	54	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			15-7-1987					0	25.2	2.3	54	Group 2 slaughtered (am).
1	185	HHH	15-5-1987	0	28.3	20.0	86					
			16-5-1987	30	27.6	18.7	98					
			17-5-1987	0.3	21.8	12.0	51					Muster slaughter groups (am). Return group 2 to holding paddock.
			18-5-1987	0	22.0	7.0	64					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			19-5-1987	0	21.6	6.0	60	0	24.6	7.6	63	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			20-5-1987					0	24.5	9.1	59	Group 2 slaughtered (am).

[1] Recorded at 9.00 am.

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
1	320	LMH	12-5-1989	0	24.9	15.0	80					
			13-5-1989	2.4	25.2	16.3	84					
			14-5-1989	0.4	25.7	16.5	82					Muster slaughter groups (am). Return group 2 to holding paddock.
			15-5-1989	0	26.6	17.0	81					Group 1 trucked to meatworks (am). Remuster group 2 (am). Group 2 trucked to meatworks (pm) due to forecasted wet weather.
			16-5-1989	0.8	25.2	18.9	85	15.6	23.4	20.3	94	Group 1 slaughtered (am).
			17-5-1989					88.2	24.2	18.6	83	Group 2 slaughtered (am).
1	320	MMM	3-3-1989	6.4	29.5	19.1	80					
			4-3-1989	0	28.6	18.9	76					
			5-3-1989	3.4	27.3	18.7	72					Muster slaughter groups (am). Return group 2 to holding paddock.
			6-3-1989	0	27.9	19.0	68					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			7-3-1989	0	29.9	18.7	72	0.2	29.1	20.9	78	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			8-3-1989					0.2	29.0	21.3	74	Group 2 slaughtered (am).
1	320	HHH	20-1-1989	0	34.1	19.6	84					
			21-1-1989	0	35.8	21.4	63					
			22-1-1989	0	35.9	20.8	65					Muster slaughter groups (am). Return group 2 to holding paddock.
			23-1-1989	24.4	36.6	19.5	70					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			24-1-1989	19.0	32.8	19.2	75	10.4	29.0	22.0	70	Group 1 slaughtered (late am). Group 2 trucked to meatworks.
			25-1-1989					0	29.1	21.8	58	Group 2 slaughtered (am).

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
2	185	LMH	10-2-1989	0	31.0	20.0	80					
			11-2-1989	0	33.2	22.2	61					
			12-2-1989	0	33.0	20.3	62					Muster slaughter groups (am). Return group 2 to holding paddock.
			13-2-1989	0	32.1	18.4	61					Group 1 trucked to meatworks (am). Group 2 remustered (am).
			14-2-1989	0	30.7	18.6	62	0	30.7	20.8	65	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			15-2-1989					0	31.3	22.1	61	Group 2 slaughtered (am).
2	185	MMM	21-5-1988	0.2	25.0	9.0	81					
			22-5-1988	0	22.5	9.5	79					
			23-5-1988	0	22.7	8.5	90					Muster slaughter groups (am). Return group 2 to holding paddock. Group 1 trucked to meatworks (late am).
			24-5-1988	0	26.2	11.2	67	0	27.1	13.0	78	Remuster group 2 (am) and trucked to meatworks (late am).
			25-5-1988					0	24.8	10.3	56	Group 1 slaughtered (am).
			26-5-1988					0	24.8	9.2	55	Group 2 slaughtered (am). (Procedure modified for expectation of pesticide residue).
2	185	HHH	11-3-1988	0	33.0	17.6	64					
			12-3-1988	0	34.1	18.1	65					
			13-3-1988	0	35.6	17.6	68					Muster slaughter groups (am). Return group 2 to holding paddock.
			14-3-1988	0	30.0	13.5	77					Group 1 trucked to meatworks (am). Group 2 remustered (am).
			15-3-1988	0	32.3	15.0	73	0	31.0	21.5	83	Group 2 trucked to meatworks (am).
			16-3-1988					Tr	28.0	21.7	74	Group 1 slaughtered (late am).
			17-3-1988					0	28.8	20.4	65	Group 2 slaughtered (late am). **(Pesticide residue testing).**

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
2	185	H^+	28-1-1988	0	33.0	19.3	52					
			29-1-1988	0	34.5	20.5	59					
			30-1-1988	0	34.9	20.0	61					Muster slaughter group (am). Return group 2 to holding paddock.
			31-1-1988	0	35.9	19.5	60					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			1-2-1988	0	36.1	18.6	62	0	34.2	23.3	70	Group 2 trucked to meatworks (am).
			2-2-1988					0.4	33.5	24.1	62	
			3-2-1988					Tr	32.2	24.3	62	Group 1 slaughtered (am).
			4-2-1988					0	31.5	21.8	51	Group 2 slaughtered (late am). **(Pesticide residue testing).**
2	260	LMH	1-12-1989	0	29.1	17.7	58					
			2-12-1989	0	29.0	15.0	65					
			3-12-1989	0	30.0	16.7	67					Muster slaughter groups (am). Return group 2 to holding paddock.
			4-12-1989	0	32.3	19.0	73					Group 1 returned to paddock (am). Remuster group 2 and hold on water for 6 hours then returned to holding paddocks. Remuster group 1 (pm).
			5-12-1989	0	32.9	22.7	64					Group 1 trucked to meatworks (am). Group 2 remustered (am).
			6-12-1989	3.2	30.7	18.0	71	0	31.9	21.2	70	Group 1 slaughtered (am). Group 2 trucked to meatworks (am)
			7-12-1989					0	33.4	21.2	65	Group 2 slaughtered (am). (Modified procedure due to industrial dispute at meatworks).

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
2	260	MMM	23-6-1989	0	19.4	5.0	86					
			24-6-1989	0	21.1	8.0	65					
			25-6-1989	0	19.0	0.6	84					Muster slaughter groups (am). Return group 2 to holding paddock.
			26-6-1989	0	15.4	2.2	74					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			27-6-1989	0	17.2	3.6	67	0	22.1	5.5	71	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			28-6-1989					Tr	20.8	11.7	77	Group 2 slaughtered (am).
2	260	HHH	10-2-1989	0	31.0	20.0	80					
			11-2-1989	0	33.2	22.2	61					
			12-2-1989	0	33.0	20.3	62					Muster slaughter group (am). Return group 2 to holding paddock.
			13-2-1989	0	32.1	18.4	61					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			14-2-1989	0	30.7	18.6	62	0	30.7	20.8	65	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			15-2-1989					0	31.3	22.1	61	Group 2 slaughtered (am).
2	260	H'	18-11-1988	0	29.5	12.6	26					
			19-11-1988	0	33.1	17.1	52					
			20-11-1988	2.0	35.0	22.1	91					Muster slaughter groups (am). Return group 2 to holding paddock.
			21-11-1988	0	29.6	17.1	71					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			22-11-1988	4.2	27.4	17.5	68	7.0	35.2	20.6	74	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			23-11-1988					4.6	36.5	21.3	66	Group 2 slaughtered (am).

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
2	320	LMH	1-6-1990	0	26.4	14.2	65					
			2-6-1990	0	22.7	7.6	76					
			3-6-1990	0	20.2	8.2	70					Muster slaughter groups (am). Return group 2 to holding paddock.
			4-6-1990	0	18.6	6.1	64					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			5-6-1990	0	20.9	8.5	76	0	20.0	14.1	72	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			6-6-1990					18.2	19.1	15.5	100	Group 2 slaughtered (am).
2	320	MMM	22-6-1990	0	22.2	6.3	67					
			23-6-1990	0	20.8	10.8	77					
			24-6-1990	0	22.0	10.8	85					Muster slaughter groups (am). Return group 2 to holding paddock.
			25-6-1990	3.4	23.0	14.2	67					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			26-6-1990	0	20.4	3.0	73	0	18.9	8.5	55	Group 1 slaughtered (am). Group 2 trucked to meatworks.
			27-6-1990					0	19.5	4.4	76	Group 2 slaughtered (am).
2	320	HHH	12-1-1990	0	34.1	21.1	71					
			13-1-1990	0	34.2	21.2	67					
			14-1-1990	0	35.1	22.8	66					Muster slaughter groups (am). Return group 2 to holding paddock.
			15-1-1990	0	38.4	23.1	63					Group 1 trucked to meatworks (am). Remuster group 2 (am).
			16-1-1990	4.6	32.2	20.7	83	18.4	33.2	22.2	94	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			17-1-1990					0.6	34.4	22.7	79	Group 2 slaughtered (am).

Animal draft	Target carcase weight (kg)	Nutritional regime	Climate recording date	Brigalow Research Station[1]				Rockhampton Meteorological Bureau[1]				Event (Refer to Figure 2 for turnoff procedure)
				Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Relative Humidity (%)	
2	320	H$^+$	20-1-1989	0	34.1	19.6	84					
		(Feedlot	21-1-1989	0	35.8	21.4	63					
		groups)	22-1-1989	0	35.9	20.8	65					Group 1 off feed (am). Group 2 remain in feedlot.
			23-1-1989	24.4	36.6	19.5	70					Group 1 trucked to meatworks (am). Group 2 off feed (am).
			24-1-1989	19.0	32.8	19.2	75	10.4	29.0	22.0	70	Group 1 slaughtered (am). Group 2 trucked to meatworks (am).
			25-1-1989					0	29.1	21.8	58	Group 2 slaughtered (am).

APPENDIX VIII

MEDIA ARTICLES

By M. R. Clarke and D. B. Strachan, beef cattle officers, Charleville

The addition of polyethylene glycol (PEG) to the diets of cattle grazing mulga increases liveweight gains.

PEG is a chemical compound, used widely in the cosmetics industry, which has the ability to bind with other compounds to form stable bonds. It has no food value and is not digested by animals.

PEG has the ability to displace the protein from the tannin in the mulga leaf and make more protein available to the animal. The way PEG works has still to be determined.

Mulga contains 10 to 12 per cent protein, which is poorly digested. Previous research suggested that the tannins in the mulga (2 to 8 per cent) bind some of the protein, making it unavailable to the animal.

At the Charleville Pastoral Laboratory, adding PEG, nitrogen, phosphorus and sulphur to the drinking water of cattle grazing mulga increased liveweight gains from 23 to 43 kg over 12 months.

The addition of only nitrogen, phosphorus and sulphur improved gains by 37kg.

In a pen study, daily drenching with PEG increased the amount of mulga eaten by weaner steers from 2 to 2.6kg, but not the digestibility of the mulga leaf. Both projects are being funded by AMLRDC.

As with many scientific breakthroughs, there is a catch — PEG is very expensive. A substitute for PEG has to be found before this technology can be used fully by livestock producers to improve the efficiency of grazing the 8 million hectares of mulga in semi-arid Australia.

Study looks at effects of nutrition

One of the most extensive studies ever undertaken to determine the effect of nutrition on meat quality has started at the Brigalow Research Station, Theodore.

The project is being funded by AMLRDC and will study the effects of nutritional setbacks on the commercial value of the carcass, the yield of saleable meat and its eating quality.

Project leader, Ian Loxton, Beef Cattle Officer, Rockhampton, said cattle raised on pasture in northern Australia commonly experienced extended periods of low weight gain or weight loss, yet there was little information on the effects on meat quality.

In June 1986, 290 Brahman cross weaners started the experiment, with another draft of 390 being added in June 1987. The study will continue until 1991.

Mr Loxton said the steers were being raised on three different planes of nutrition from weaning to slaughter at carcass weights of 200, 260 and 320 kg.

One plane of nutrition would give constant growth rates while the other planes approximated commercial conditions. The range of carcass weights covered the different market requirements.

During the pre-slaughter period, growth rates would be recorded, and carcass weight at slaughter. Yield of saleable meat and meat qualities such as tenderness rating, cooking loss and nutritional analyses would be measured post-slaughter.

If commercially significant differences between planes of nutrition were measured, it would be necessary to develop commercially viable methods to implement the preferred growth rate pattern, said Mr Loxton.

Feedlot vacancy

Vacancy signs will be hanging out on many feedlots in 1988 if we have a normal summer rainfall, according to Ken Howard, Beef Cattle Adviser, Toowoomba.

He said while close to 250,000 cattle passed through Queensland's feedlots this year — which is over 11 per cent of the State's total slaughterings — this figure could be cut by half in 1988.

Feedlotting, he said, made a major contribution to Queensland's beef industry, especially in 1987.

Without feedlots there would have been plunging store prices and lower quality beef for both the export and overseas markets.

Ken Howard said while the feedlots were good for the industry in maintaining a continuity of high-quality beef, this was only one side of the story.

Many cattle, he said, would have cost more money in the feedlot than they returned. Much of this was because prices for finished cattle had not risen high enough by the time they were sold.

Cattlemen, he said, should give care to their costings and make realistic estimates of the finished value of their cattle.

"Nicely finished cattle can lose their attraction if their total cost is not more than covered by their selling price," he warned.

Qld Farmer & Grazier

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Beef Lines in [illegible]

vice as we know it today, is set to change radically in the next five to 10 years.

The ice was broken by the Tasmanian Government which introduced fee-for-service several years ago.

The New Zealand Department of Agriculture and Fisheries "privatised" in March 1987 in a bid for cost recovery.

In the past 20 years, there has been a strong move towards specialisation in government. At the same time, there has been a trend towards diversification in industry.

extension services by both sectors in the future.

There are several good reasons why the trend towards private consultants will accelerate over the next decade. Firstly, there is the need for reduced government expenditure.

Governments now feel that primary producers should be prepared to pay for advice which directly affects the profitability of individuals and that services will be used more productively if they are paid for.

Industry is beginning to want accountability for the advice and services and advice is unlikely to be in the system too long.

There is an increasing need for "whole farm" advice.

In the near future, it is most likely that the bulk of extension services will be handled by private individuals who are very familiar with all aspects of primary production within a region or district.

For example, a property running sheep and cattle currently calls on at least two extension officers, but has no one to help put the two enterprises together in the most profitable way.

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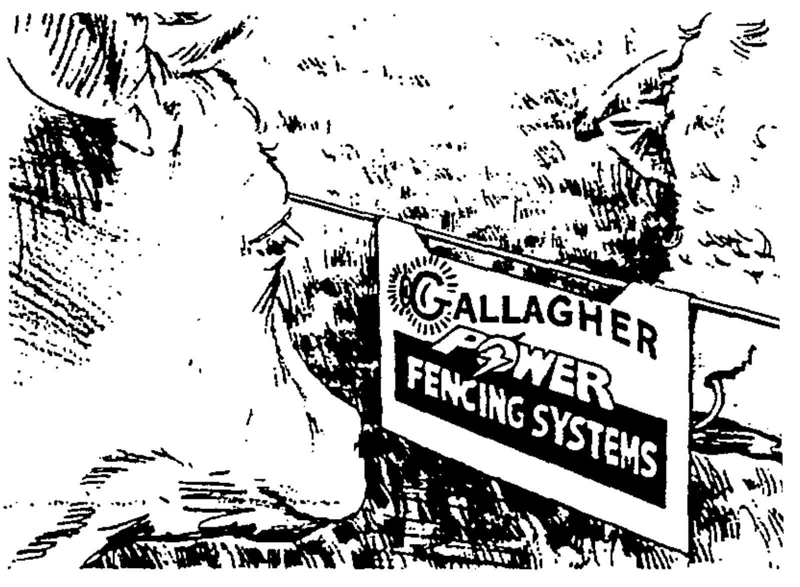

POST WEANING NUTRITION AND CARCASS QUALITY

A study of the relationship between dietary setbacks in commercial cattle and meat quality is underway at the Brigalow Research Station, Theodore.

The project, one of the most extensive studies undertaken in Australia, is funded by the AMLRDC and is being run in conjunction by the DPI and CSIRO.

The study will examine the effects of nutritional setbacks on the commercial value of the carcass, the yield of saleable meat and its eating quality.

Beef Cattle Officer at Rockhampton and project leader, Ian Loxton, said cattle raised on pasture in northern Australia commonly experienced extended periods of low weight gain or weight loss. "There is little information about the effects of this on meat quality," he said.

The experiment started in mid 1986 with 290 Brahman cross weaner steers under the eyes of researchers. Another 390 head were added in mid 1987 and the experiment will continue until 1990.

Mr Loxton said the steers were being raised on three different planes of nutrition from weaning to slaughter. One plane would give constant growth rates, while the other planes approximated commercial conditions.

During the pre-slaughter period, growth rates would be recorded and checked against the carcass weights at the time of slaughtering. Yield of saleable meat would be estimated, while meat qualities, such as tenderness, and nutritional value will be measured post-slaughter, he said.

Cattle will be slaughtered at three different average, weight levels - 185kg, 260kg and 320kg. These levels represent the different market requirements. Some steers have already been slaughtered at the 185kg level which represents local trade carcass weights.


Ian Loxton examining carcasses at Lakes Creek, Rockhampton.

Preliminary results from this first draft show little variation in meat toughness for the three different planes of nutrition. Most animals have produced meat perceived as tender to most people, with only a small number producing unacceptable meat.

Increased meat toughness is due to shorter muscle fibres and more connective tissue in the muscle.

In addition, as growth rates decline there is less external fat on the carcass at the rump site, although there is not a corresponding reduction in fat within the muscle.

Regardless of the growth rates until the 185kg slaughter weight, the fat levels within the muscle were very low, ranging from an average 1 to 1.4 percent.

Results are being collected on steer carcasses that average 260kg and 320kg. These carcass weights are suitable for the US and Japanese markets.

"If commercially significant differences between planes of nutrition were measured, it would be necessary to develop commercially viable methods to implement the preferred growth rate pattern," Mr Loxton said.

COMPUTERS HELP DROUGHT MANAGEMENT

Successful drought management depends not only on surviving the drought financially but also being able to rebuild herds and financial stability as soon as possible after droughts.

Successful drought management usually involves feeding, agisting or selling cattle and often a combination of all three.

The classes and numbers of cattle sold can have a marked effect on both surviving the drought and the time taken to recover after the drought.

Peter Smith a Beef Cattle Husbandry Officer and Bill Holmes an Economist with the QDPI, with the co-operation of some cattlemen from the Charters Towers area, compared two selling strategies with a computer herd model, early in 1988.

Computer modelling is proving to be a convenient way of comparing cattle management practices. One model developed by Bill Holmes can compare herd development and gross margins over a period of 10 years.

Selling all male cattle and retaining breeders was compared to selectively selling females and a small number of steers. In both cases the stocking rate was reduced by about one third.

The rationale for these two strategies is based on the facts that cows are more expensive and difficult to feed in droughts and are not as convenient as steers to agist. Further, male sales provide the majority of income for northern cattlemen, are easier and cheaper to feed and provide a flexible agistment proposition.

In this comparison, accepted cattle performance estimates, four year old bullock turnoff and cattle market values current in March, 1988 were used.

Using these values selling females, was by far the better option in terms of regaining financial viability after the drought. The model showed that selling females to create cash flow following the drought in the male selling option produced insufficient income to cover operating costs for up to four years. This accumulated debt took a further three years to recoup.

With the female selling option, males were available for sale immediately following the drought. These sales produced sufficient income to cover operating costs and produce a profit from year two.

Computer herd models are not infallible but they can be a useful tool in calculating the likely outcomes of property management decisions.

6- Focus on Beef, March 1989

from the relatively lean, well muscled B2 steers as the better finished 4 score steers required more trimming. The poorest performers were from the lightly muscled, "wastey" D4 carcases.

These results have important ramifications for butchers and supermarkets who buy their carcases from wholesalers, on a cold carcase weight basis.

The interesting feature of tables one and two is that the research data show just how powerful fat scores and live muscle scores can be in predicting the outcome of the two processing stages of the beef industry.

Fat measurements vs visual

Three measures of carcase fatness were used in the project:

1. P8 fat depth measured on the hot carcase
2. 12/13th rib fat depth measured on the cold quartered carcase
3. A visual fat score using the Ausmeat fat scoring system (1-6)

Often, the standard of dressing and carcase trim affects the reliability of fat depth measurements. In this project, the standard of dressing was extremely high and the carcases were carefully inspected for uniformity of trim by Ausmeat area managers.

In Table 4 the r^2 values show how each of the three methods compare, in explaining variation (%) in retail yield and fat trim. This data demonstrates that subjectively made visual fat scores are comparable in accuracy to fat depth measurements made at the 12/13th rib on a cold quartered carcase.

Table 4: R^2 values, showing how each of the three methods compare in explaining variation in retail yield and fat trim.

	Retail yield (kg)	Fat trin (kg)
P8 rump fat depth (mm)	20.3	48.0
12/13th rib fat deoth (mm)	30.4	60.8
Visual fat score (1—6)	30.5	55.8

Fat depth measurements made at the P8 rump site were disappointing. We are unable to say why. The site itself, the measuring technique and carcase temperatures may all have been contributing factors.

Live animal description: The addition of a live muscle score to liveweight and fat scores currently used in describing live animals substantially improves our ability to predict retail yield.

These results justify a decision made by the Meat Industry Authority of NSW to include live muscle scores in its livestock market reporting service.

There are many good grounds to have live muscle scores adopted nationally in market reports.

Marketing: Live muscle scores are currently being used by Calm. Some abattoirs are contemplating using carcase muscle scores on which to base premiums.

Since both live and carcase musc scores relate so closely to retail profit they provide a perfect parameter c which to base premiums and discounts.

The success of such industry-adapt incentives will hinge on the competenc of assessors — about which there is cu rently some doubt.

Breeding: Remember that as Sol says, o ain't oils. Liveweight represents but o stage in the beef chain.

Since only about one third of an a mal's liveweight is sold as meat, its usef ness is limited as a selection criteria if i creasing retail yield is your object.

Accompanying liveweight selection a live muscle score is a sensible way achieving better growth without loss carcase quality.

In selecting muscle, don't go ov board. Fertility and mothering ability a still the most important economic tra so let them govern your selection for i proved carcase characteristics.

Summary of results

- At the same liveweight and fat dep each increase of one muscle score turned to the butcher an extra $57 on average carcase.
- Dressing percentages increased 1.7% for each increase in live mus score at the same liveweight and cover.
- Retail yield increased by 1.5% for ea increase in live muscle score at the sa liveweight and fat cover.
- Fat trim increased by 1.kg per carc for each unit decrease in live mus score.
- Live muscle scores were highly co lated with carcase muscle scores (0. and eye muscle areas (0.68).
- Carcase muscle scores were good in cators of retail yield % (r^2 = 25). A meat butt profiles were disappointing = 3).
- Fat depth measurements at the 12th and visual fat scores were more accur in predicting both retail yield (%) and trim (kg) than fat measurements made the P8 rump site.

This paper was prepared a recent Beef Indus Association seminar at Albury/Wodonga. was based on research funded by the Aus lian Meat and Live-stock Research and De opment Corporation, carried out by Sa Yeates, Bill McKiernan, Diana Perry, other NSW Agriculture & Fisheries officer

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Central Qld beef found low in fat

Steaks from Central Queensland Brahman cross steers are low in fat, according to a study of carcase quality and post-weaning nutrition. It examined effects of nutritional setbacks on commercial value of the carcase, the yield of saleable meat, and its eating quality.

The project is funded by the Australian Meat and Live-stock Research and Development Corporation, the Queensland Department of Primary Industries, and the CSIRO.

During the study the fat content of rib fillet steak was between 1.1% and 4.2% — low enough to please the most ardent cholesterol watcher. In addition, steaks from grain fed steers contained no more fat than those from grass fed steers — good news for consumers who enjoy grain fed beef and want to maintain a low-fat diet.

Beef cattle officer at Rockhampton and project leader Ian Loxton said cattle raised on pasture in northern Australia commonly experienced extended periods of low weight gain or weight loss. The study was started because "There is little information about the effects of this on meat quality."

The study had shown that pre-slaughter stress and cold shortening may be as important as post-weaning nutrition in influencing meat quality. Pre-slaughter stress from farm handling practices, transport methods, selling systems and handling at the meatworks could result in tough meat. Cold shortening — the contraction of muscle fibres in carcases during chilling — is, Mr Loxton said, the major post-slaughter factor that can toughen meat.

"All the good work involved in feeding cattle to grow and finish can lead to tough meat if handling, transport and chilling techniques are not up to scratch."

FactFinder

Want to find out more about feeding cattle for the autumn-winter market. The WA Department of Agriculture has published a bulletin detailing the practicalities of feeding-up cattle for this often lucrative seasonal market. See "FactFinder" on page 46 for details.

PRIME BEEF PRODUCER
Vol. 2, No. 3, August 1989

Vol. 2, No. 3, Augu

Genetic selection key to consistent tender beef cuts

Genetic selection for meat tenderness could be the future key to provide the domestic consumer and the beef importer with consistently tender meat products.

With support from the Australian Meat and Livestock Research and Development Corporation, a Queensland Department of Primary Industries research effort is analysing aspects of meat quality working in collaboration with the CSIRO Meat Research Laboratory, Cannon Hill and two QDPI Brisbane laboratories.

Spokesman for the project, Ian Loxton, Beef Cattle research officer, Rockhampton, said the initial work was launched four years ago because there was little available information on the effect of post-weaning nutrition relating to growth rates in Brahman cross cattle between weaning and turnoff.

Inconsistancy of meat quality is the critical issue that must be addressed by the Australian beef industry.

Mr Loxton said, "Importers are buying to carcase specifications but we have measured a wide variation in aspects such as meat tenderness, fat cover and meat colour."

"And while this is of concern to the importer, it is the ultimate consumer who will really drive the market of the future by demanding a consistent, tender red m product in a balanced nutritio diet."

Mr Loxton said, "Through extension of the current Breedp philosophy, we will be looking at heritability of meat qua indicators."

Genetic progress can be m when a trait is variable and herita This is the case with meat ten ness.

The research project attempting to address the inc sistent quality issue by derivin rigorous objective selection appro to identify animals that will defini yield a tender, consistent product.

Please turn to Page

Continued from Page 26

our land resource therefore avoiding over-grazing."

Mr Loxton said the Brigalow Research trial chose the growth enhancers, Avotan and Compudose 200 and 400. The enhancers were not being evaluated alone, but in combination with proven protein supplementation technology developed in North Queensland.

At Berrigurra, weaners treated with a growth promotant but turned onto winter oats returned a liveweight gain advantage during May-October up to 60 kg/head. Weaners not on the oats but given a 0.75 kg daily intake of protein supplement during the May-October period at Berrigurra last year recorded similar gains. In previous trials where 0.5 kg/day protein supplement was fed, the advantage gain was 40 kg.

Mr Loxton said, "We have found that weaners coming out of the first winter with a 40 kg advantage tend to maintain that advantage through to turnoff."

By getting weaners moving in that initial winter-spring period and then maintaining that performance, turnoff could be reduced from the current 3 - 3 1/2 years down to 24-30 months.

With animals maintaining high growth rates, producers will have the flexibility to market stock with adequate fat coverage and weight onto newly developing export markets rather than always being retained for the heavyweight Japanese market.

The earlier turnoff potential will enable cattlemen to target Korea, Taiwan and the US primal cut markets which specify lighter, younger, table quality carcases. Mr Loxton believes the incentive is there as importers were demanding a more youthful product.

Although it is the producer who is best qualified to judge the benefits of marketing steers a year earlier, it would require cattlemen to boost management efficiency with rigorous culling of non-producing breeders. This would ensure sufficient weaner steers were produced to maintain herd productivity.

The Brigalow Research Sta trial also found that when ste reached 460 kg liveweight, quality of available feed insufficient to maintain them high growth rate – a legacy of sev frosting of pasture.

Mr Loxton said, "This has bee barrier to achieving a 30-month s turnoff so we are monitoring quality to identify the limit nutrients."

It has been suggested the fros buffel pastures were ene deficient so the next step will b concentrate on supplying ene supplements or more judicious of grazing crops during the ani second winter-spring.

Berrigurra weaners sup mented with protein at wea were turned off to Jap ox s ifications at two years by finis off through a feedlot situation maintaining high growth rates weaning, grassfed Japanese t steers could be turned off a months but producers would have flexibility to sell younger st to meet alternative potential ma situations.

Continued from Page 5

Best showring performance for Imperator bull progeny came from Apis Creek Max, a reserve senior bull at Rockhampton, Mackay and Brisbane Royal Show.

Third was between three sires contesting their first Register of Renown season.

Jeff and Ann McCamley's Don Eligio 26/2 (imp US) scored 87 points to take third. Most successful Don Eligio off-spring was Lancefield D Don Camelo, senior and grand champion at Toowoomba and reserve senior at Townsville and Roma.

Ron Kirk and family, Yenda Stud, Gayndah, scored 74 points with five progeny of JDH Mr Manso 613/7 (imp US). Senior and grand champion bull at Rockhampton and Mackay Shows was Yenda Broadway. Junior champion heifer at Rockhampton and Mackay was Yenda Miss Mirage.

Nine junior progeny of Solo Tuxubaya earned 5th place and 64 points for Solo stud operated by Dave Simpson and family, Ridgelands.

1989 Dam of the Year was Warragun Stud's Warragun Helen, a double victory for Tim and Kath Garle. Warragun Helen progeny earned 69 points for the show season.

Second with 52 points was the imported dam, McKellar Miss Jumbo, owned by Bill and Rhonda Inslay, Cocos Brahman Stud,
Rochelle Downs Embryo Centr
Marmor. Cocos also took third pla
with Cocos Lambie on 20 point
Fourth with 17 points was Warrag
Rose owned by Tim and Kath Gar
Lancefield's imported dam, GM In
Fecundo, was fifth with sho
progeny earning 16 points.

▼ APIS CREEK MAX – one of t
winning progeny for seco
placegetter in the 1989 Sire of t
Year, WHS ANDY IMPERATOR.

Continued from Page 31

Mr Loxton said, "In addition to measuring carcase length and depth, samples of the cube roll are forwarded for laboratory assessment."

The CSIRO was measuring meat fibres for toughness together with indications of meat colour and pH.

Research was also recording marbling - the intra-muscular fat - as well as the chemical extraction of all fat in the samples. Taste panels also evaluated tenderness, juiciness and flavour to compliment the mechanical measurements.

Mr Loxton said, "To produce meat suitable for the Australian domestic market, growth rates from weaning and turnoff needed to be better than 0.58 kg/head/day."

The trial also showed for the US primal cut markets where age was not a major specification at this stage, any growth rate between 0.43 and 0.58 kg/hd/day from weaning were acceptable.

To meet the Japanese grassfed market specifications, growth rates of 0.49 kg/hd/day or better between weaning and turnoff were required.

At this stage, it was not possible to say that any one nutritional plane or growth rate was better than another to result in a more tender product.

Mr Loxton said, "We have identified pre-slaughter stress as a contributing factor to inconsistent quality of meat."

Meat sample pH readings were taken to assess pre-slaughter stress.

The project has endeavoured to standardise all pre-slaughter procedures using the same stock handlers, road transport operators and meatworks, yet the pH readings of the trial slaughter stock were much higher than expected.

Despite rigid standardisati
procedures, pre-slaughter stress w
still occurring for unknown reason

Mr Loxton said that processi
factors such as chilling and electri
stimulation were also close
monitored.

Regarding fat content relating
the cube roll steak, content vari
from 0.8 percent for the Australi
domestic carcase through to
percent on the average Japane
market carcase.

Mr Loxton said there was
significant difference between
content of grainfed cattle and th
which were grassfed.

From assessment of 600 Brahm
cross cattle in the current trial a
from 200 head in a previo
experiment, the Brahman cr
carcase was lean with a low
content of which people were v
conscious.

Meat tenderness is related to nutrition, pre-slaughter stress and processing sectors but **Ian Loxton** believes genetic selection could be key to consistent tender beef cuts.

Genetics for tenderness

In the push to provide tender meat for exporters and domestic consumers the key could be genetic selection. With support from the Australian Meat and Livestock Research and Development Corporation, a Queensland Department of Primary Industries research effort at its Brigalow Research Station, Theodore, is analysing meat quality.

The work is being done in collaboration with the CSIRO's meat research laboratory at Cannon Hill and two of the department's Brisbane laboratories.

Ian Loxton, Queensland Department of Primary Industries research officer, said the work was launched four years ago because there was little information on the effect of post weaning nutrition relating to growth rates in Brahman cross cattle between weaning and turnoff.

"Inconsistency of meat quality is the critical issue that must be addressed by the Australian beef industry. Exporters are buying to carcase specifications but we have measured a wide variation in aspects such as meat tenderness, fat cover and meat colour.

"Ultimately, it is consumers who will drive the market by demanding a consistent, tender, red meat product in a balanced nutritional diet.

"Through an extension of the current Breedplan philosophy we will be looking at the heritability of meat quality indicators. Genetic progress can be made when a trait is variable and heritable. This is the case with meat tenderness."

Mr Loxton said future research projects will handle the issue of inconsistent quality with a rigorous but objective selection approach to identify animals that would definitely yield a tender, consistent product.

The CSIRO was measuring meat fibres for toughness together with indications of meat colour, and pH to assess pre-slaughter stress. Research was also recording marbling — the intra-muscular fat, as well as the chemical extraction of all fat in the samples.

Taste panels evaluated tenderness, juiciness and flavour to complement the mechanical measurements.

At this stage it was not possible to say that any one nutritional plane or growth rate was better than another for a more tender product. As turnoff groups have been less than 42 months of age, then age related meat toughness has not been an issue in this project. There was no significant difference between fat content of grain-fed and grass-fed carcases of the same weight.

Pre-slaughter stress had been identified as a contributing factor to inconsistent quality of meat from Brahman and Brahman cross cattle.

"The project team standardises all pre-slaughter procedures using the same stock handlers, road transport operators and meatworks, yet the pH readings of the trial slaughter stock were much higher than expected."

Despite rigid standardisation procedures, pre-slaughter stress was still occurring for unknown reasons and requires further research.

Mr Loxton said that processing factors such as chilling and electrical stimulation were also closely monitored.

Vol.3, No1, July/Aug 1990

Meat quality not a clear cut issue

Post weaning nutrition for grassfed Bos indicus steer has little or no influence on the tenderness and colour of meat samples from the loin.

But recent Queensland research findings show nutritional levels do have a direct effect on growth rate which is reflected in the age of turnoff.

Age has a great influence on tenderness and preliminary evidence suggests that younger, 320 kg carcase grain-supplemented steers averaging 2.5 years produced more tender meat because of a reduction in the amount of connective tissue. Meat colour was also superior.

This messages comes from Queensland Department of Primary Industries beef cattle husbandry officer, Ian Loxton, who has co-ordinated a trial conducted by the QDPI and the CSIRO Meat Research Laboratory at Cannon Hill, Brisbane.

The comprehensive northern Australian research project involved 625 Brahman cross steers (ranging between 50-70% Brahman content) split into two nutritional regimes at the QDPI's Brigalow Research Station, Theodore.

The nutritional planes were low, medium, high and medium, high and very high. Those subjected to a very high post weaning to slaughter nutritional regime were grain supplement.

Mr Loxton said the program aimed to determine whether the post weaning plane of nutrition influenced meat quality and carcase yields at slaughter weights of 185kg, 260kg and 320kg reflecting the requirements of the Australian domestic, U.S. primal cut and Japanese markets.

"Overall, loin samples were of average tenderness but there was greater variation associated with tenderness, indicating that an unacceptable proportion of samples were tough," he said. "Factors contributing to this variation included pre-slaughter stress/management, electrical stimulation and the chilling regime."

From the 21 slaughter groups analysed, liveweight gains ranged from 0.34 to 0.74 kg/head/day between weaning and turnoff from the 185kg, 260 kg and 320 kg groups.

"The minimum difference in time to turnoff between the very high nutritional groups and the other groups was 43 days to 185 kg carcase weight, 52 days to 260 kg carcase weight and 304 days to 320 kg carcase weight," Mr Loxton said. "As nutrition improved, rump fat and eye muscle increased and carcase skeletal depth and length tended to decrease at the 185kg and 260kg carcase weights."

Mr Loxton said the results indicated that north Australian-produced Brahman cross beef was low in fat, a fact which should be acknowledged by Australian consumers.

"In 185kg carcases, the total fat percentage ranged from 0.84% to 1.36%; in 260kg carcases it ranged from 1.66% to 2.43%; and in 320kg carcases it was 3.61% to 4.41%," he said. "Marbling was minimal but acceptable for proposed grassfed markets, while meat colour was acceptable with minimal dark cutting."

Mr Loxton said that three of the high growth rate turnoff groups suffered from pre-slaughter stress.

"We believe the possible causes contributing to this stress appeared to be high daily temperatures, additional waiting time due to pesticide residue testing or exposure to strange animals pre-trucking or during trucking," he said.

"A less than effective electrical stimulation system combined with a fast chilling regime could be expected to produce tougher loin muscles. Under a similar chilling regime with an effective stimulation or one with a slower cooling rate there is less cold shortening.

"The cold shortening effect was especially noticeable in the lighter carcases which contributed to meat toughness. Chilling rates are slower for carcases with a heavy fat cover," he said.

New feedlotting books from Qld

The rapidly expanding feedlot industry is the subject of two new Queensland Department of Agriculture publications, "Feedlotting — A Guide for Beef Producers" and "Lot Feeding in Australia".

The former is a 96-page book which addresses improved feedlot management and profitability. It contains comprehensive information for both existing lot feeders and those thinking about entering the industry, and covers all aspects of lot feeding, including design and establishment, economic aspects, waste management, feed ration preparation, marketing and animal health. It also discusses potential problems and outlines ways of avoiding pitfalls and minimising the potential environmental impact of feedlots.

The second, "Lot Feeding in Australia", is a 146-page survey of the Australian lot feeding industry, which now earns the country more than $420 million a year in exports and $100 million a year domestically.

Complied by the QDPI's Feedlot Services Group to address concerns about the industry's rapid growth and the risk of environmental pollution, the report describes the industry in terms of capacity and distribution, and discusses its proposed expansion and the feedlot types, sites and design. Other sections cover waste, feed and animal health practices.

The publication would interest regulatory bodies such as local authorities and other people contemplating entering the industry.

"Feedlotting — A Guide for Beef Producers" and "Lot Feeding in Australia" are for sale at selected QDPI country outlets or the QDPI Bookshop, Primary Industries Building, Brisbane for $15 or $50 respectively. Alternatively, they can be ordered by mail from QDPI Publications, GPO Box 46, Brisbane, 4001 for $19 and $57.50 respectively (including postage and handling). The mail-order cost of both books is $72.50, including postage and handling.

Vol. 4, No. 1 July/Aug. 1941

Vol. 6, No 6, July 1991

BEEF IMPROVEMENT NEWS

Lifting the quality of Bos indicus beef

LIKE it or not, research has shown that beef from northern Bos indicus cattle lacks consistent quality and tenderness.

Some cynics may say they've known this for years.

CSIRO and Queensland Department of Primary Industries (QDPI) studies have pinpointed the reasons why, and they are now recommending that producers aim for earlier turnoff of slaughter stock from improved pastures/crops to help redress the problem.

The two major components of meat tenderness/toughness are the toughness of the muscle fibre bundles and toughness caused by the type and extent of connective tissue.

Discussing the problems at the Future for Beef conference, QDPI meat researcher, Ian Loxton said muscle fibre bundle toughness could be influenced by:

- Pre-slaughter stress - which also caused dark-cutting meat and
- Cold-shortening - fast chilling of carcases after slaughter shortens and toughens the muscle fibres.

Mr Loxton said effective electrical stimulation after stunning would overcome the effects of cold-shortening, but electrical stimulation was not as effective if pre-slaughter stress had occurred and dark-cutting meat had resulted.

Connective tissue consists of different types of proteins around the muscle fibres and its contribution to meat toughness is largely influenced by the age of the animal at slaughter.

In general, the younger the animal is at slaughter, the less the contribution connective tissue has to toughness.

So producers should aim at turning slaughter stock off earlier.

The consensus at the conference was that northern producers should be moving to turn-off steers at no older than 2.5 years, rather than the traditional 3 to 4 years and older.

Poor seasons aside, Mr Loxton said this could best be achieved by selecting faster-growing, earlier-maturing bulls combined with improved nutrition.


Ian Loxton

Not only would better nutrition boost growth rates, it would also raise the level of external fat cover on slaughter stock. Greater fat cover would reduce cold-shortening problems in the chiller and also contribute to improved tenderness.

Mr Loxton said Bos indicus breeds were naturally very lean and there was little chance of improved nutrition leading to overfat problems.

He said improving pastures, especially with the new species of stylos, coupled to conservative stocking rate was the first step to better *feeding*.

Producers with suitable country should consider winter oats/grain crop or lot-feeding, and all producers should make use of a single, long-acting growth promotant at weaning.

By lowering turn-off age, Mr Loxton said producers would not only improve tenderness but also meat and fat colour, because younger animals tended to have lighter meat and whiter fat - now very much favoured by the trade. On the problem of dark-cutting meat, he said the solution was to minimised pre-slaughter stress.

Growth promotants

GROWTH promotants are safe, they should be used, and the pressure to have them banned was purely politically-based.

That was the clear message to producers at the Future for Beef conference from Colorado State University's professor of meat science, Gary Smith.

Professor Smith, who is one of the world's leading meat researchers and beef industry consultants, left delegates in no doubt where he stood on the controversial issue.

"Anabolic steroids are safe. The World Health Organisation, the U.S Food and Drug Administration, as well as Professor Eric Lamming who headed the European Community's own investigation, have all said they're okay.

"Anabolic steroids are okay used as hormone growth promotants in cattle and we should be using them."

Professor Smith said it would be impossible to feed the world's population without science and technology.

During "hunter-gatherer" times, he said the world supported a population of 30 million. Now its population was 5.3 billion and g

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BRIGALOW RESEARCH STATION

RESEARCH PROGRAM INFORMATION

1990

a. INTRODUCTION TO THE STATION
b. SOIL MANAGEMENT RESEARCH
c. PASTURE RESEARCH
d. CATTLE NUTRITION AND MEAT QUALITY RESEARCH

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EFFECT OF POSTWEANING NUTRITION ON CARCASE YIELD AND MEAT QUALITY

AIM AND SIGNIFICANCE

To determine whether the postweaning plane of nutrition influences carcase yield and meat quality at a range of slaughter weights.

About one third of the Australian beef herd (8 M head) is located in northern Australia of which 80% have a *Bos Indicus* content. The annual turnoff of the northern herd approaches 2 M head. These cattle are grown out and finished under a wide range of nutritional environments, which may result in periods of low or negative growth rates. Despite this, there is little evidence to determine whether the pattern of growth after weaning has any significant effect on meat yield or meat quality in pasture-based systems.

Brahman cross weaner steers at the Queensland Department of Primary Industries Brigalow Research Station, Theodore are being grown out at different controlled growth rates using a combination of different stocking rates and supplementation/forage crops. The animals in each treatment group of 96 will be slaughtered at one of three target weights; either 185, 260 or 320 kg to meet the local, US or Japanese markets respectively.

To assess meat quality, samples of the cube roll are collected at slaughter and analysed for protein, fat content, ultimate pH, meat colour, shear force, cooking loss, marbling fat and eating quality.

AN R + D PROJECT CARRIED OUT BY THE QDPI IN CONJUNCTION WITH CSIRO AND FUNDED BY THE AUSTRALIAN MEAT AND LIVESTOCK RESEARCH AND DEVELOPMENT CORPORATION

Q.D.P.I.

CSIRO

R&D CORP

AUSTRALIAN
MEAT AND LIVE-STOCK
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D. CATTLE NUTRITION AND MEAT QUALITY RESEARCH

There has been a marked change in the composition of beef exports to Australia's overseas customers. In 1989 there was a decline in beef exports to the US (50 000 t reduction), compared to 1988. The major proportion of export meat to the US market is a manufacturing product. In contrast, there was an increase in the export of high quality beef to Japan (a 41 000 t increase) and Korea (a 49 000 t increase). Current indications suggest an increasing demand for the export of high quality beef to Korea.

With the current emphasis on supplying a suitable product for high quality beef markets it is probable that younger animals will be turned off in Northern and Central Queensland.

The Brigalow regions of Central and Southern Queensland are capable of supporting pastures that will average 180 kg liveweight per head annually. However, owing to variable seasonal conditions, annual gains will vary from about 140 to 230 kg per head. Due to the capacity to grow grain and forage crops as well as pasture, these seasonal influences can be reduced, therefore Brigalow regions are well placed to meet the challenge of producing a younger high quality beef product.

The objective of the current research program at Brigalow Research Station is to explore methods by which high quality beef can be consistently produced over a range of seasonal conditions.

Nutrition and Growth Rate

Future animal production will have to be flexible in order to meet changing market requirements and take advantage of market opportunities as they occur. There is a trend toward producing carcases from younger animals which will require annual liveweight gains greater than 180 kg per head so market requirements can be met.

The productivity of *Bos indicus* cross weaners between weaning and slaughter at 320 kg carcase weight is being monitored in a number of experiments at Brigalow Research Station. Weaner steers at conservative stocking rates (1 steer/2 ha) produce annual liveweight gains of 200 kg/hd in the first year post weaning. In the second year post weaning, these animals will produce annual liveweight gains of 150 kg/hd.

When improved nutrition is offered to similar weaners during the June to October period following weaning, liveweight gains can be improved by 40 kg resulting in annual gains of 240 kg/hd in the first year. This improvement was due to a combination of protein supplements, rumen modifier and a hormonal growth promotant. In another group of weaners given a hormonal growth promotant only, an annual liveweight gain of 230 kg/hd was achieved. To date, a combined treatment of protein supplement, rumen modifier and hormonal growth promotant following weaning will maximise liveweight gains over the first year, however a hormonal growth promotant alone will give the best economical advantage in the first year.

The experiments have also shown that high growth rates achieved in the first year post weaning cannot be maintained in the second year post weaning.

A current experiment on the station is being carried out to increase winter spring growth rates of weaners in their second year post weaning using protein supplements, rumen modifier and a hormonal growth promotant to achieve a reduction in turnoff age. In addition, one treatment in this experiment has been designed to minimise internal and external parasite stress in weaners. To date, (august 1989 to May 1990) tyhis treatment has resulted in a 19 kg advantage in liveweight gain.

A new experiment on the station commencing in June 1990 will investigate grain supplementation in each winter spring period between weaning and slaughter. This experiment will be carried out on buffel on buffel/seca pastures and will not involve hormonal growth promotants.

Meat Quality

One of the major pre-requisites for high quality meat markets is tenderness, while other traits such as colour, juiciness, flavour and fat content are also important. A major project is being undertaken at Brigalow Research Station in conjunction with the CSIRO, Meat Research Laboratory, Cannon Hill and with financial support from the Australian Meat and Livestock Research and Development Corporation to define some of the nutritional factors necessary to produce high quality beef. This study is based on examining the effect of different rates of liveweight gain on meat quality parameters of carcases weighing 185, 260 and 320 kg. The post weaning rates of gain being examined are 80, 130, 180 and 300 kg per head annually.

Trends to date include:

- Average daily gains greater than 0.58 kg/hd/day post weaning are necessary to produce carcases suitable for the Australian domestic market (180 to 200 kg) in terms of age and weight specifications.

- To meet age and carcase weight specifications, average daily gains greater than 0.43 kg/hd/day and greater than 0.49 kg/hd/day of animals are necessary between weaning and slaughter to be suitable for the Korean and Japanese grass fed markets respectively.

- With increasing carcase weight, rump fat cover, carcase length and depth and eye muscle area all increase. Also, when grain is fed either as a long term supplement or in a feedlot situation, eye muscle area increases.

- Marbling increases with increasing carcase weight, while meat surface colour is unaffected by carcase weight or growth rate. However, grain fed animals may produce brighter meat.

- Meat tenderness/toughness in this project has been influenced by nutrition, pre-slaughter stress and carcase chilling procedures. There are two components of meat toughness - myofibrillar (muscle fibre) contribution and connective tissue contribution to tenderness/toughness.

- Cube roll samples from carcases in this project have been of average tenderness, however there is a larger variation in the tenderness values being recorded. Myofibrillar (muscle fibre) toughness has been responsible for the meat toughness recorded in the project, and myofibrillar toughness is most affected by pre-slaughter stress and carcase chilling procedures. Because of these factors, it has been difficult to identify the influence of nutrition in most cases to meat tenderness/toughness. There is no clear trend in meat tenderness due to carcase weight either.

- Connective tissue toughness is age related and as most animals in this project are less than 3.5 years at turnoff, then the contribution of the cube roll connective tissue to meat toughness in cube roll samples has been minimal. Connective tissue toughness increases significantly in animals over four years of age. However, in primal cuts other than the cube roll or rump, connective tissue assumes an increasing importance even in younger animals. This age related factor becomes of greatest importance in animals over four years of age when all primal cuts are affected.

- The fat content (intramuscular and intracellular) of cube roll samples increases with increasing carcase weight. There is little difference in fat content due to nutrition, also difference between grass fed and grain fed carcases suitable for the Japanese market are minimal. Brahman cross meat, either grass fed or grain fed, is a low fat product, with ranges in the average fat content and the different groups - 0.93 to 1.66% for the Australian domestic market, 1.66 to 2.4% for the Korean market and 3.91 to 4.39% for the Japanese market.

The production of high quality animals must be matched by correct on farm handling practices, efficient transport methods and selling systems plus correct handling at meat works to minimise bruising and avoid pre-slaughter stress. In addition, post slaughter factors including electrical stimulation and a correct chilling techniques are equally important. The combination of these factors are essential to achieve a high quality end product.

New projects planned for Brigalow Research Station will investigate the meat quality of heifers, paddock grain supplemented steers suitable for the Korean market and younger aged animals suitable for the Japanese market. In addition, other projects planned will investigate improving the yield of saleable meat from cull empty or lactating cows.

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QDPI BRIGALOW RESEARCH STATION
PROJECT SUMMARY
AUGUST, 1991

LAND MANAGEMENT RESEARCH

"Management of Solidic and Clay Soils"

P. Lawrence, B. Radford, A. Key

Solidic and clay soils in cleared brigalow lands are at an increased risk of degradation when cropped. Physical soil characteristics and conventional farming practices may not sustain productivity. A three year project is examining the effect of soil type and tillage on run-off, erosion and wheat productivity (STREP).

More specifically, STREP is investigating the effects of conventional and zero tillage practices and levels of stubble cover on seedling establishment, wheat productivity, soil erosion, surface run-off and soil water for clay and solidic type soils in the Dawson Valley region. Results will be used to develop cropping systems that are productive and conservative and still acceptable to the industry.

For the first time since 1986, the zero till wheat grain yield of 1383 kg/ha was less than the conventional till yield of 2222 kg/ha. This response may be associated with a concentration of nutrients in the zero till soil surface which was not utilised by the wheat crop during an extremely dry 1990 winter season. Water use efficiency was also better in the conventional till treatment (12 kg/ha/mm) than in the zero till (6 kg/ha/mm). Under heavy rainfall, it was also shown that late in the fallow, zero till produced more run-off than conventional tillage. Development of a surface seal in zero till suggests that growers should include a cultivation operation late in the fallow to break up the seal, increase water infiltration and mix surface nutrients. Zero till continues to provide the greatest reduction in soil loss because of the high levels of surface cover maintained during the fallow.

"Brigalow Catchment Study"

P. Lawrence, B. Radford, A. Key, B. Cowie, T. James, E. Anderson

The Brigalow Catchment Study investigates the consequences of clearing brigalow forest on catchment hydrology, soil fertility, productivity and groundwater salinity. Three experimental catchments (12-17 ha) supporting brigalow were monitored over an 18 year period. In 1982, one was cleared and cropped to wheat from 1985 and another sown to pasture in 1983 and then grazed. The third remains as brigalow forest. Clearing has doubled annual run-off. Under cropping, average run-off changed from 26 mm to 56 mm/yr while clearing for pasture increased run-off from 23 mm/yr to 47 mm/yr. Soil erosion losses were greater off the cropped catchment. Productivity of wheat and pasture has not deteriorated eight years after clearing although cropping is more exploitive of soil nutrients. Lack of groundwater recharge indicates

"Renovation of Run-Down Sown Grass Pastures"

G. Robbins, T. James, C. Esdale

Results from renovating old run-down buffel pastures has given inconsistent productivity responses since experimentation began in 1987 at Brigalow Research Station. Up until this year, the renovation with a single, severe cultivation has not improved production. This year it did.

Last year, cattle grazing the renovated buffel paddocks had liveweight gains of 165 kg/head compared with the unrenovated paddocks with 156 kg/hd. Seasonal conditions were less favourable this year so cattle on the untreated paddocks gained 103 kg/hd from July 1990 through to May 1991. Production from the paddocks renovated in December 1989 returned average liveweight gains of 130 kg/hd. The obvious benefit was more pasture of better quality with fewer woody weeds.

It seems that renovation is more likely to pay on soils that are fertile, when the pasture is considerably run-down and when there is sufficient rainfall after renovation.

BEEF RESEARCH

"Nutritional Liveweight Gains of *Bos indicus* Cross Weaners by use of production Supplements or Growth Enhancers."

I. Loxton, T. James, T. Mullins, G. Blight, R. Holroyd, T. Ryan

Bos indicus cross weaner steers implanted with Compudose 400 and others treated with a growth promotant with additional protein supplementation and rumen modifier produced heavier and longer carcases when turned off at three years.

The supplements were offered in winter/spring following weaning. These HGP plus supplemented weaners also produced carcases with slightly more subcutaneous fat cover, marginally greater eye muscle area and a higher predicted saleable meat yield. These steer carcases returned a higher carcase value and more of them graded suitable for the Japanese grassfed market.

These were the major findings from a trial designed to improve the lifetime productivity of *Bos indicus* cross weaners using post-weaning supplements alone or in combination with growth enhancers.

The combination of supplements, rumen modifier and HGP at weaning produced the highest value carcase. However, steers implanted with HGP only at weaning returned the highest change in gross margin over the control group at turnoff. The supplementation without HGP achieves a short term liveweight response which is not retained through to turnoff because of the effect of compensatory liveweight gain.

This experiment showed that use of an HGP minimised the compensatory gain effect and improved animal liveweight gain to greater than 190 kg/hd between weaning and 30 months. The potential to reach the carcase weight criteria (four permanent teeth and 300 kg HSCW) at turnoff is greatly enhanced.

"Maximising Liveweight Gains of *Bos indicus* Cross Cattle Grazing Improved Pastures on Brigalow Lands using Supplementation in Successive Years."

I. Loxton, T. James, M. Jeffery, A. Whyte, T. Mullins, G. Blight, R. Holroyd, T. Ryan

Liveweight gain improvements between weaning and 30 months was similar for *Bos indicus* cross steers given protein supplement/rumen modifier/Compudose 400 following weaning or when given the same treatment 12 months later aged 18 months. The liveweight advantages were 37 kg and 42 kg respectively.

Protein supplement intake was doubled for the older steers. Supplements were offered in winter/spring. For steers given protein supplements and implanted sequentially in both years following weaning, the improvement in liveweight gain was lower (27 kg) compared to an HGP treatment at either weaning or at 18 months. Sequential use of HGPs may result in diminishing liveweight performance.

Steers given supplements and implanted with HGPs in both years recorded the greatest liveweight advantage of 50 kg. These steers had also been treated frequently with Ivomec, Bayticol and Barricade S to minimise external and internal parasite burdens.

The only positive change in gross margin per steer was achieved using the supplement and HGP regime in the first year after weaning. This change in gross margin over the control group was $11.88/hd with remaining treatments recording high losses due to higher input costs.

The lifetime performance of Simbrah steers at 30 months given the supplement/HGP regime in each year (plus the parasite treatments) returned average carcase weights of 323 kg. Compared to carcases from Brahman/British steers from previous experiments, the European cross steers had less subcutaneous fat cover and a lower dressing percentage. AUSMEAT Chiller Assessment indicates the Simbrah carcases had whiter fat and brighter meat.

"Maximising Annual Liveweight Gains on Buffel/Seca Pastures to Achieve a Reduction in Turnoff Age of Steers."

T. James, M. Jeffery, A. Whyte, I. Loxton.

Feeding a grain supplement to weaner steers between mid-August and mid-December, 1990, produced a liveweight advantage to the fed steers of 20 kg (12 %) on buffel grass pasture and 26 kg (10 %) on buffel grass/seca stylo pasture. In the following April, 1991, the weight advantage had been maintained but the percentage advantage had been eroded to 5.9 % and 7.6 % respectively.

The objective of the experiment is to achieve a 200 kg liveweight gain per year (0.55 kg/day) for Brahman cross steers from weaning to turnoff at approximately 620 kg liveweight using grain supplementation when growth rates are not meeting the target. The experiment is on-going through until May, 1992.

"Energy Supplementation to Increase the Net Value and Improve Meat Quality of Finishing Steers for the Korean Market."

M. Jeffery, T. James, A. Whyte, R. Shorthose, I. Loxton, G. Blight

Bos indicus cross steers that were short fed in the paddock with an ad-lib grain ration had higher growth rates resulting in earlier turnoff suitable for the Korean grassfed market.

All grain supplemented steers were turned off by 125 days compared to 190 days for unsupplemented steers. The grain supplemented steers had heavier carcases due to a higher dressing percentage while subcutaneous fat cover and eye muscle areas were not consistently increased.. Grain provided no appreciable improvement in subcutaneous fat colour, surface meat colour, marbling or fat content of striploin meat samples. Short term grain supplementation had little or no influence on meat tenderness as striploin meat samples from all turnoff groups were off average tenderness. The major factor responsible for the average meat tenderness was cold shortening. The connective time contribution to meat tenderness was high in some groups. Pre-slaughter stress was not considered a problem in this experiment. Its apparent absence was responsible for reducing the overall variation in muscle fibre bundle tenderness. These were the findings of the first draft of an experiment to measure the effects of a high energy supplement on growth rates, subsequent market suitability and meat quality of steers for the Korean Grassfed market.

"Effect of Different Post-Weaning Nutritional Pathways on Carcase Yield and Meat Quality"

I. Loxton, R. Shorthose, T. James, T. Mullins, G. Blight, R. Holroyd, A. Neill, S. Rogers, T. Ryan.

Post-weaning nutrition had no direct effect on the meat quality of *Bos indicus* cross steers (50-70 % Brahman). However improving nutrition results in a reduced turnoff age which will improve meat quality. In the project, steers from a grain supplemented group aged approx. 2.25 years and slaughtered at 320 kg carcase weight produced more tender meat that was of a brighter colour.

Overall, loin samples were of average tenderness but there was great variation associated with tenderness. Factors responsible for this variation (apart from genotype) include pre-slaughter stress/management, electrical stimulation and chilling regime. Post-weaning nutrition did influence carcase composition of steers slaughtered at 185 kg and 260 kg mean carcase weights but not the composition at 320 kg mean carcase weight.

The cost of grain feeding to significantly reduce turnoff age in this project was prohibitive with breakeven sale prices (including interest) ranging from $2.45/kg dressed weight to $2.88/kg dw. Cheaper alternatives to the grain feeding regime used in the project would be required in order to significantly reduce turnoff age and retain current industry preferred carcase weights. Fat content of the lean steak samples taken from the loin of the *Bos indicus* cross steers is low - the result being lean beef. At carcase weights of 185 kg, 260 kg and 330 kg, the respective average fat contents were 1.1 %, 2.1 % and 4.1 %.

"Effect of Time of Slaughter and Nutritional Regimes on the Value of Cull Cow/Calf Units and the Yields of Saleable Meat from Lactating Cows"

M. Jeffery, T. James, A. Whyte, I. Loxton, T. Ryan, G. Blight

Findings from the first draft of an experiment to improve the carcase yield and value of cull cows and their calves showed liveweight gains of 30 kg and carcase gains of 35 kg were achieved with cull cows either after 'Early Weaning' or 'Ad-lib Grain Feeding' in the paddock.

Similar cows within the 'Control' group and from the cow/calf group where the 'Calves only had access to Creep Feed', the liveweight and carcase gains were 9 kg and 7 kg respectively. Rump fat depths and yields of saleable meat were the highest in the Early Weaning cow group (13.2 mm; 80 kg) and lowest in the Creep-Fed cow group (4.5 mm; 65 kg).

Average daily gains for the Control and Early Weaned calves were both 0.77 kg/hd/day while the Ad-lib grain fed and Creep-fed calves were 0.82 kg/hd/day and 0.89 kg/hd/day respectively.

Carcase weights of the calves were in direct contrast to the cows. Creep-fed calves had the heaviest carcases (118 kg) followed by the Controls (112 kg), Ad-lib grain fed (106 kg) and Early Weaned calves (103 kg).

Grain intakes for the groups varied from 9 kg/cow-calf unit/day for the Ad-lib grain fed group to 3.5 kg/hd/day and 1.9 kg/hd/day for the Early Weaned and Creep-Fed calves respectively.

The change in gross margin over the initial slaughter group from the culled pregnant cows was $120/cow when calves were retained and sold at three months of age. Further increases in gross margin change over selling pregnant cows were made by keeping cows and calves longer before sale. Marginal benefit to cost ratios increased to 3.58 for cows and calves maintained on pasture only but decreased as costs of inputs increased.

"Seasonal Growth and Carcase Yield of Grazing Steers Implanted with Trenbolone Acetate and Oestradiol"

G. Tudor, T. James, R. Hunter, T. Magner, I. Loxton

This trial studied the effect of Revalor on seasonal growth, carcase weight and fatness of Brahman crossbred steers in Central Queensland. Ninety-three steers grazed improved pasture 15 months prior to slaughter. The first 25 weeks (Sept-March) they were divided into two groups. One draft was implanted to Revalor (140 mg trenbolone acetate plus 28 mg oestradiol-17B mixed with cholesterol) and the other left as a control. The treated steers gained weight at 0.57 kg/day, significantly faster than the untreated steers at 0.44 kg/day.

The two groups were then divided into two sub-groups. One sub-group from each group was then implanted with Revalor initially and again four months later. The other sub-groups remained as controls. This second period was of nine months duration and ended with the slaughter of the steers in December. Animals treated with Revalor at some time during the experiment had significantly heavier liveweights at slaughter by approximately 22 kg and had significantly heavier carcases by 13 kg approximately when compared with the untreated animals. Steers implanted nine months before slaughter had significantly less subcutaneous fat at the P8 rump site than those not treated or those implanted earlier than nine months pre-slaughter.

In conclusion, the big stimulation to liveweight gain occurred after implantation with Revalor for the first time. Any response to a second implantation was small by comparison. The Revalor treated steers had a carcase weight advantage ranging from 11 kg to 17 kg. Sustained treatment with Revalor before slaughter changed the way nutrients were partitioned in such a way that a leaner carcase resulted providing a $25 increase in financial return.