MEAT & LIVESTOCK AUSTRALIA

On farm

Effect of Protected Nutrients in Feedlot Rations

AGRICULTURE VICTORIA
A business of the Department of Natural Resources and Environment

Natural Resources and Environment
AGRICULTURE • RESOURCES • CONSERVATION • LAND MANAGEMENT

CSIRO

FLOT.207

Final Report prepared for MLA by:

Jenny Davis[A] ,
Suresh K Gulati[B],
John R Ashes[B], and
Peter Speck[AC]

[A]Agriculture Victoria, Rutherglen,
[B]CSIRO, Animal Production, Prospect, Sydney
[C]SARDI, Adelaide,

Meat and Livestock Australia Ltd
Locked Bag 991
North Sydney NSW 2059

ISBN 1 74036 462 7

May 1999

Feedlots

TABLE OF CONTENTS

PART 1: ABSTRACT

Meat & Livestock Australia Ltd funded this study to 1) assess under controlled conditions the effect of protected nutrients on beef cattle feedlot performance and carcass quality, 2) evaluate sequential ultrasound scanning as a means of predicting the marbling performance of cattle being fed in a feedlot situation, 3) assess the cost: benefit of using protected nutrients to enhance feedlot performance and carcase quality, and 4) to make recommendations on the practical industry application of the investigated products and techniques.

The study showed that inclusion of Marble Plus™ in a feedlot ration increased both visual (marble score) and chemically measured intramuscular fat. The increase in percent intramuscular fat was 2.3 units, ie 8.33% control vs. 10.59 Marble Plus™ and led to a significant ($P<0.01$) increase in carcass value.

Cattle fed protected lipid and protein had higher proportions of C18 (di- and tri-) unsaturated fatty acids (C18:2; C18:3) than did control cattle and this led to a decrease in the melting point (mp) of the subcutaneous fat to below 25^{o}C.

The are two benefits for human health from feeding protected nutrients to ruminants. Firstly the lower mp will allow boning rooms to be held at lower temperatures and thereby increase meat safety. Secondly the increase in unsaturated fatty acids may have a positive impact on human health.

Under the conditions of this trial the ultrasound scanning did not accurately predict marble score or the percent of intramuscular fat of the trial cattle. Use of sequential scanning did not result in any improvement in the ability to predict marble score or percent intramuscular fat.

From an economic analysis of the results it was shown that all the treatments added value to the finished product. Protected starch was the most profitable followed by control and Marble Plus™. From consideration of the physiological and economic data it is strongly recommended that further work be conducted to: -

a) develop a feeding regime that gives similar increases in marbling found in the present trial but that reduces the cost of treatment,

b) determine the number of days on feed that is necessary to produce marbled cattle suitable for the Japanese B3 market, and

c) explore the physiological mechanisms that lead to increases in marbling with no increase in subcutaneous fat.

PART 2: EXECUTIVE SUMMARY

(i) Objectives

Meat & Livestock Australia Ltd funded this study to 1) assess under controlled conditions the effect of protected nutrients on beef cattle feedlot performance and carcass quality, 2) evaluate sequential ultrasound scanning as a means of predicting the marbling performance of cattle being fed in a feedlot situation, 3) assess the cost: benefit of using protected nutrients to enhance feedlot performance and carcase quality, and 4) to make recommendations on the practical industry application of the investigated products and techniques.

(ii) Brief methodology

Two hundred and eleven Murray Grey steers (from Willalooka Pastoral Company, South Australia) were studied. They were put into the Rutherglen Research Feedlot at an average weight of 508 kg and fed for 156 to 190 days on one of four rations. The rations were control, protected starch (control ration with 10% protected wheat substituted for 10% wheat), Marble Plus™ (control ration with 10% protected starch and 10% protected lipid and protein) and M2+ (control ration with 20% protected starch and 10% protected lipid and protein). Pen feed intake was recorded daily and steers were weighed at monthly intervals and assessed by ultrasound on days 98 and 128 and on the day before they were slaughtered.

Steers were killed in three groups on days 156, 176 or 190. Carcass grades and fat depth were estimated using accredited AUSMEAT assessors and fat and muscle samples were taken for intramuscular fat content and fatty acid profile assessment.

(iii) Main results and conclusions

The study showed that inclusion of Marble Plus™ in a feedlot ration increased both visual (marble score) and measured intramuscular fat. The increase in the percent of intramuscular fat was 2.3 units and led to a significant increase in carcass value.

Cattle fed protected lipid and protein had significantly higher proportions of di and tri unsaturated fatty acids (C18:2; C18:3) than did control animals and this led to a decrease in the melting point (mp) of the subcutaneous fat to below 25°C. Benefits for human health are two fold from feeding protected nutrients. Firstly the lower mp will allow boning rooms to be held at lower temperatures thereby increasing meat safety. Secondly the increase in unsaturated fatty acids may have a positive impact on human health.

Under the conditions of the trial ultrasound scanning did not accurately predict marble score or the percent of intramuscular fat of the trial cattle. Use of sequential scanning did not result in any improvement in the ability to predict marble score or percent intramuscular fat over the initial scan.

An economic analysis of the data showed that all treatments added value to the finished product. The most profitable was the starch treatment followed by the control and Marble Plus™ treatment groups.

It was concluded from the study that inclusion of Marble Plus™ in barley and wheat-based rations significantly increased the amount of marbling in feedlot cattle.

(iv) Recommendations

- That protected starch be included in barley and wheat based rations as a method to increase the number of cattle meeting market specifications for the Japanese B3 market.

- The use of protected nutrients be considered as a viable option for increasing meat safety by allowing chillers to be maintained at lower temperatures.

- A further investigation to assess the timing of introduction of protected nutrients in feedlot rations to determine the most profitable feeding regime be conducted. The economic analysis showed that a small reduction in cost of Marble Plus™ treatment would generate significant gains to the Jap Ox segment of the feedlot industry.

- The physiological and biochemical mechanisms responsible for the increase in marbling be examined in a further study with protected nutrients to allow greater scope for the manipulation of marbling.

- A further study be conducted to calibrate the ultrasound scanner for use with feedlot cattle with an intramuscular fat percentage of eight or greater.

PART 3: THE REPORT

1. Introduction

Improving the efficiency of utilisation of feedstuffs in the feedlot industry represents one of the few alternatives available to maintain and improve enterprise profitability. This is possible because the rumen of cattle has evolved to efficiently utilise fibrous material for the provision of nutrients for absorption in the small intestine. However, this type of digestion is relatively inefficient, and represents a major cost in the feedlot finishing system. The cost is not only in the feed but the penalties incurred for not meeting market specifications.

One way to overcome the inefficiencies of the rumen is for nutrients to be protected against breakdown in the rumen, thereby allowing them to bypass it. This can be achieved by treating nutrients to render them resistant to microbial degradation in the rumen. Lipid, protein and starch can all be protected from rumen degradation and can be used to design rations that are matched to specific physiological endpoints with respect to growth and carcass composition. The use of protected nutrients has been shown to increase intramuscular fat deposition in cattle (Ashes et al. 1993, Gulati et al. 1995). However, the performance of some commercial protected nutrient products in the Australian feedlot industry has been inconsistent. One very important difference in the rations used in the current experiment is the combination of the protected starch with the protected protein and lipid. Commercial trials to date have only used a combination of the protected protein and lipid. The reason for these inconsistencies remains unclear. However, it could relate to variations in diet specifications, or the genetics or backgrounding characteristics of the animals. Meat & Livestock Australia Ltd funded this study to assess under controlled conditions the effect of protected nutrients, when fed as part of a feedlot ration, on beef cattle feedlot performance and carcass quality. The study also assessed the use of sequential ultrasound scanning as a means of predicting the marbling performance of cattle being fed in a feedlot situation.

2. Objectives

- To evaluate the effect of a protected starch product (Rumentek), alone and in combination with protected protein and lipid, on beef cattle feedlot performance and carcass quality, when fed as part of a feedlot ration.
- To assess the use of sequential ultrasound scanning as a means of predicting the marbling performance of cattle being fed in a feedlot situation.
- To assess the cost/benefit of using protected nutrients to enhance feedlot performance and carcase quality, and
- To make recommendations on the practical industry application of the investigated products and techniques.

3. Materials and methods

Two hundred and eleven Murray Grey steers (Willalooka Pastoral Company, South Australia) of similar liveweight and age were used in the study. The steers had been backgrounded on lucerne flats before feedlot entry. All animals were treated for internal and external parasites and given a 5 in 1 vaccination at the start of the trial and then given a booster 5 in 1 vaccination after 4 weeks. Groups of 17 or 18 animals were assigned to one of three replicates in four treatment groups on a random and equal liveweight basis and given barley and wheat based rations as follows:

Group I: Control ration
Group II: Ration containing 10% protected starch (Starch)
Group III: Ration containing 10% protected starch and 10% protected lipid and protein (Marble Plus™)
Group IV: Ration containing 20% protected starch and 10% protected lipid and protein (M2+)

The ingredients and chemical composition of the four different rations are given in Table 1. The protected starch supplement was prepared from wheat and the Marble Plus™ from canola, soybean and sunflower oilseeds by Rumentek Industries Pty Ltd, Moree, NSW, using procedures developed by CSIRO. The lucerne silage and oaten hay were chopped through a Kverneland Silachop, the barley and wheat were cracked using twin rollers in a Hawk mill (Keogh Sons Manufacturing Pty Ltd, Eaglehawk, Victoria). The metabolizable energy content and crude protein of the rations were determined using FEEDTEST (Pastoral & Veterinary Institute, Hamilton, Victoria). The steers were introduced to the ration over a 3-week period and during this phase the protected nutrients were gradually increased. The experimental rations were offered ad libitum daily to the steers for 156 to 190 days. The feed intake data are presented on a dry matter basis. Animals were weighed monthly at the same time of day before the morning feed. All steers were scanned using ultrasound on days 98 and 128 and on the day before they were slaughtered as an aid in prediction of intramuscular fat. A proficiency-tested scanner recorded the ultrasound images with an ALOKA 500 machine using a 3.5MHz/172mm linear probe. The digitised images were stored and sent to AGBU for analysis with the Iowa State University interpretation system USOFT(TM).

Table 1. Composition of experimental rations

Ingredient	Control	Starch	Marble Plus™	M2+
	(%, DM basis)			
Lucerne Silage	5	5	5	5
Oaten Hay	10	10	10	10
Lupins	8	8	6	6
Barley	36	36	32	32
Wheat	36	26	22	12
Protected Wheat	0	10	10	20
Protected protein and lipid	0	0	10	10
Lime	1	1	1	1
Molafos 4%	4	4	4	4
Chemical composition				
CP%	13.9	14.0	15.5	15.5
ME, MJ/kg DM	11.7	11.6	12.0	11.9

The animals were slaughtered in three groups in a commercial abattoir after either a 156, 176 or 190 day feeding period. The hot dressed carcass weights were recorded. Dressing percentage was calculated from the ratio of hot dressed weight and final liveweight. Independent operators using AUSMEAT procedures and classifications (AMLC 1986) estimated carcass grades and fat depth after the carcasses had been chilled for 72 h. Subcutaneous fat samples were obtained immediately after slaughter and fatty acid profiles were determined using procedures described by Christie (1989). Muscle samples (from the 12th rib site) were taken 72 h after slaughter and frozen at –20 ^{0} C. Intramuscular fat content was determined on minced samples of muscle that were carefully trimmed of seam fat using the methods of the AOAC (1997).

3.1 Statistical Analysis

Statistical significance was assessed by Analysis of Variance and REML (the method of residual maximum likelihood) using the statistical package, Genstat 5 (Genstat 5 Committee 1993). Daily weight gains were calculated by dividing the liveweight gain over the number of days and are calculated only for the first 126 days, as this was the period when all animals were weighed at the same time. Feed intake was assessed on a group basis and so statistical assessment was only made for the period 0 to day 126.

4. Results

4.1 Growth, slaughter and carcass characteristics

There were no significant differences in average daily gain (ADG), feed conversion efficiency (FCE), dressing percentage, hot standard carcass weight (HSCW), or fat depth between the treatment groups (Tables 2 and 3). The average payment received per carcass was significantly higher ($P < 0.01$) for steers from the Marble Plus™ treatment group.

Table 2. Performance of Murray Grey steers fed a feedlot ration with or without protected starch, Marble Plus™ or M2+.

Treatment	Initial Lwt, kg	Final Lwt, kg	ADG[1]	FCE[2]	HSCW[3]	Dressing %
Control	504	723	1.72	9.54	416	54.90
Starch	508	732	1.75	9.44	421	55.10
Marble Plus™	506	731	1.76	9.21	424	55.16
M2+	502	730	1.79	8.85	425	54.87

[1] average daily gain, kg/d - measured from day 0 to day 126.
[2] feed conversion efficiency (kg feed consumed per kg liveweight gain) measured from day 0 to day 126 (average per pen).
[3] hot standard carcass weight (kg)

4.2 Marble score and intramuscular fat content

4.2.1 Visual marbling Score

Visual assessment of carcasses tended to underestimate the degree of marbling when compared to the intramuscular fat content (See Table 3). This difference is due to the very soft nature of the fat.

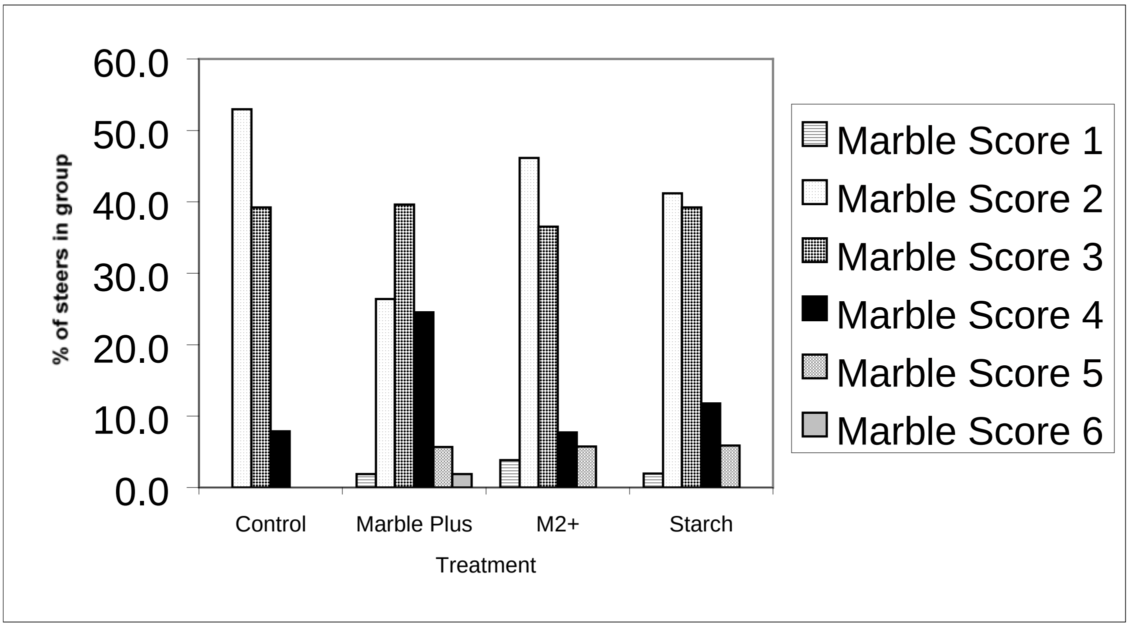
Table 3. Carcass quality of Murray Grey steers fed a feedlot ration with or without protected starch, Marble Plus™ or M2+. Mean values within columns having different superscripts are significantly different (P<0.05).

Treatment	Payment[1]	Fat Depth[2]	Marble Score	% Fat[3]
Control	$1,271[a]	22	2.55[a]	8.33[a]
Starch	$1,326[ab]	22	2.78[ab]	9.46[ab]
Marble Plus™	$1,382[b]	22	3.11[b]	10.59[b]
M2+	$1,316[a]	22	2.65[a]	9.99[b]

[1] average price paid per carcass
[2] fat depth (mm)
[3] intramuscular fat content (% as is)

Inclusion of Marble Plus™ in the ration significantly increased the mean visual marbling score above the control animals. The inclusion of protected starch by itself tended to increase marbling score (control: 2.55, starch: 2.78) but this was not statistically significant ($P>0.05$). Similarly, the inclusion of M2+ also tended to increase visual marbling scores from 2.55 control to 2.65 but this was not significant. Figure 1 shows the effect of nutritional treatment on marble score. The control treatment had 98% of steers with Marble score of 2 or 3 whereas 72% of the steers in the Marble Plus™ group had marble scores of 3 or higher and the starch group had 41% in Marble Score 2 and 39% in the Marble 3.

Figure 1. The effect of nutritional treatment on Marble Score



4.2.2 Intramuscular fat content

Intramuscular fat content of meat samples is presented in Table 3. Both Marble Plus™ and M2+ treatments significantly ($P< 0.05$) increased the intramuscular fat content from a mean of 8.33% (for control) to 10.59 and 9.99 for Marble Plus™ and M2+ respectively. Protected starch alone tended to increase the intramuscular fat content but this was not significant.

Both visual and fat extraction assessments support the hypothesis that the inclusion of the three protected nutrients (ie. protein, starch and fat) enhanced the deposition of intramuscular fat in cattle during the fattening phase of the growth curve.

4.3 Ultrasound scanning

Scatter plots of marble score and percentage intramuscular fat vs predicted intramuscular fat (PIMF) are presented in Figures 2 - 4. The relationship between marble score, the percent of intramuscular fat (as analysed) and PIMF is not precise, although there appears to be an underlying trend for marble score to increase with scanning value. When percent intramuscular fat is graphed against PIMF there is evidence of a trend with percent fat increasing with PIMF score but the relationship is poor. Sequential scanning of the cattle did not result in any improvement in the ability to predict marble score. The USOFT software used to interpret the scanning results was developed by animal researchers at the Iowa State University, Iowa, USA on American feedlot steers and heifers in the range of 2-8 % intramuscular fat. Outside this range the analytical software commonly identifies parameters outside a specific range and will not provide a prediction.

Within animal this is more often the case for the images, which would provide the higher readings, leading to biases in higher marbling animals, as only the images with "less" IMF will be analysed. Further research and development at the Animal Genetics and Breeding Unit, UNE, Armidale using data from Australian feedlot cattle may overcome this problem.

Figure 2. Marble score at slaughter versus predicted intramuscular fat on day 98 of Murray Grey steers finished in a feedlot for 156 to 190 days

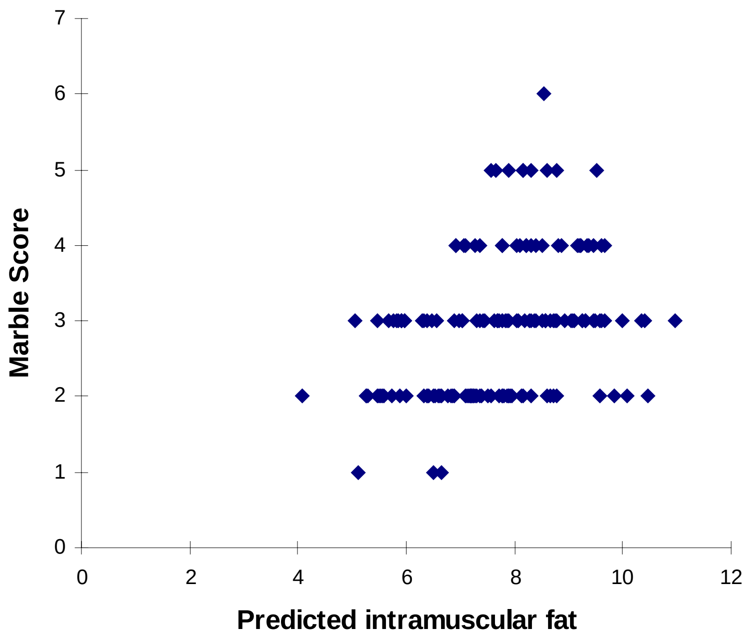


Figure 3. Marble score at slaughter versus predicted intramuscular fat on day 128 of Murray Grey steers finished in a feedlot for 156 to 190 days

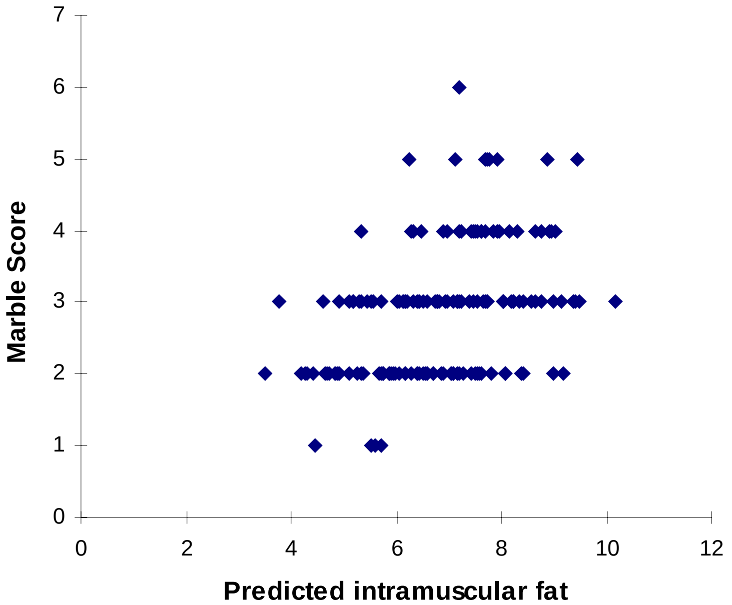


Figure 4. Marble score at slaughter versus predicted intramuscular fat on the day before slaughter of Murray Grey steers finished in a feedlot for 156 to 190 days.

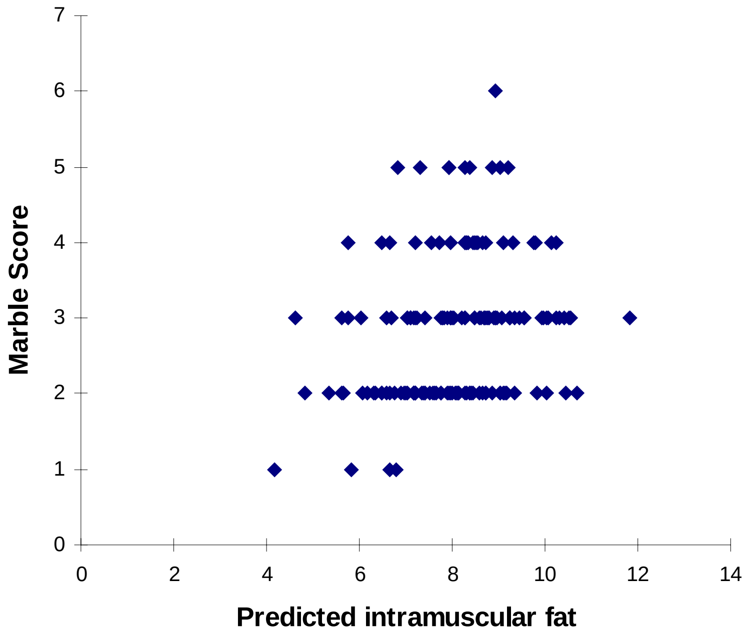
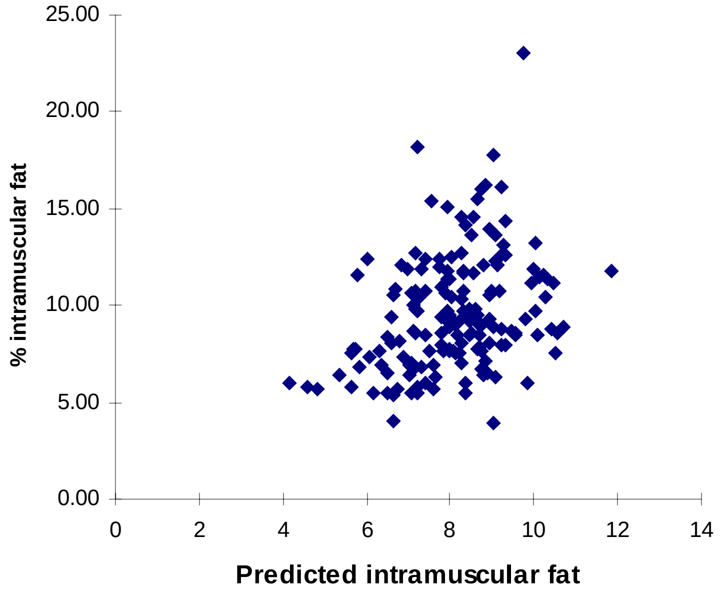


Figure 5. Percent intramuscular fat content at slaughter versus predicted intramuscular on the day before slaughter of Murray Grey steers finished in a feedlot for 156 to 190 day



4.4 Fatty acid composition and melting point

The fatty acid profile of subcutaneous fat samples taken adjacent to the 11 to 12th rib is summarised in Table 4. Inclusion of the Marble Plus^{TM} and M2+ in the ration significantly ($P < 0.05$) increased the proportion of linoleic (18:2) and linolenic (18:3) acids in subcutaneous fat. The source of protected fat used in the Marble Plus^{TM} was a blend of canola and soybean oilseeds and hence this would provide additional 18:1, 18:2 and 18:3. The magnitude of change in these fatty acids in subcutaneous fat of cattle that received Marble Plus^{TM} was less than that reported previously for lighter cattle where cattle had an initial live weight of 278 kg and final live weight of 444 kg (Ashes et al. 1993). This difference is due to the larger amount of endogenous fat present in the animals that had an average initial live weight of 508 kg at the commencement of fat supplementation. It must also be noted that the intramuscular fat increased significantly with Marble Plus^{TM} and this would indicate more 18:1, 18:2 and 18:3 deposition in these animals.

All animals had a high proportion of C18:1 *cis* fatty acids and relatively low proportions of C18:0 (see Table 4) that reflects a very active Δ 9 desaturase system induced either by the composition and digestibility of the diet or the genotype and background of the Willalooka Murray Grey cattle used in this trial.

Independent AUSMEAT assessors at the abattoir commented on the softness of the fat in all cattle. This is directly related to the fatty acid composition. The sum of the saturated, mono and polyunsaturated *cis* fatty acids and the ratio between unsaturated and saturated acids is presented in Table 5. In this trial, the ratio of unsaturated/saturated acids in subcutaneous fat from all cattle was greater than 1.75 and that iss indicative of a melting point (mp) less than 30°C (see Pethick et al. 1997). This ratio tended to increase with the inclusion of Marble Plus^{TM} (see Table 5) and this would make the fat slightly softer and lowered the mp. The mp of subcutaneous fat from approximately 17 cattle from each treatment group is presented in Table 5. All of these values are less than 30°C. Moreover, the inclusion of Marble Plus^{TM} tended to reduce the mp of fat from 26.95°C (for control) to 24.81°C. For comparison, the ratio of unsaturated to saturated fatty acids in subcutaneous fat from pasture fed cattle is less than 1 and the mp is approximately 42°C.

Table 4. The effect of nutritional treatment on the fatty acid profile of subcutaneous fat from Murray Grey steers fed a feedlot ration with or without protected starch and Marble Plus^{TM} or M2+. Mean values within columns having different superscripts are significantly different (P<0.05).

Treatment	C14:0	C14:1t	C16:0	C16:1t	C18:0	C18:1	C18:2	C18:3
Control	2.463^{b}	0.3863^{b}	22.83^{b}	0.814^{b}	7.43	50.20	1.082^{a}	0.2886^{a}
Starch	2.325^{ab}	0.3788^{b}	22.15^{ab}	0.876^{b}	7.53	51.28	1.188^{a}	0.2971^{a}
Marble Plus^{TM}	2.416^{b}	0.3327^{a}	22.14^{ab}	0.721^{a}	7.67	50.30	2.128^{b}	0.5815^{b}
M2+	2.288^{a}	0.3117^{a}	21.33^{a}	0.713^{a}	7.66	51.26	2.328^{c}	0.6106^{b}

Table 5. The effect of nutritional treatment on the sum of the saturated, mono and polyunsaturated *Cis* fatty acids, their ratio and melting point of subcutaneous fat from Murray Grey steers fed a feedlot ration with or without protected starch and Marble Plus^{TM} or M2+. Mean values within columns having different superscripts are significantly different (P<0.05).

Treatment	Sum (saturated)	Sum (unsaturated)	Ratio (unsaturated/saturated)	Melting Point[1]
Control	33.39	59.39^{a}	1.81	26.95^{b}
Starch	32.65	60.00^{ab}	1.86	24.98^{ab}
Marble Plus^{TM}	32.90	60.32^{b}	1.87	24.81^{ab}
M2+	32.10	61.34^{b}	1.94	23.55^{a}

[1]Melting point of fat (^{o}C)

4.5 Economic analysis of data

Economic analysis of the data was done (see Appendix 1) and it was shown that all treatments added value to the finished product. The treatment costs considered were the feed costs for each treatment group. It was assumed that other costs (induction, animal health etc) were similar for all groups and were therefore not included in the budget.

The analysis showed that adding protected starch to the ration, though it did not significantly increase percentage fat in the carcases, was the most profitable treatment. The next most profitable treatments were the control and Marble Plus™. The analysis showed that if costs of Marble Plus™ could be reduced by 5% large increases in profitability could be achieved. It has been estimated that a 12% reduction in costs could be achieved if protected starch was fed for the initial period followed by Marble Plus™ for the last 80 days of the feeding period. Physiologically this capitalises on matching the animal's requirement for increased lipid intake during the period of greatest deposition of intramuscular fat.

A cost/benefit study (Appendix 2) was done on the basis that additional research on the timing of Marble Plus™ feeding would result in a cost reduction of the Marble Plus™ program in the order of 5 to 15%. If costs were reduced by 10% the cost/benefit analysis showed that there would be a return of $6.74 for every dollar spent which represents a net present value of $5.74 million to the industry. The analysis assumed that there were 150,000 cattle on feed destined for the Japanese B3 market. This figure is conservative and latest MLA data suggests that the number may be closer to 240,000 head, this would result in even greater returns to the industry.

5. Conclusions

(a) Inclusion of a combination of protected starch, protected protein and protected lipid (Marble Plus^{TM}) in high grain feedlot rations increased visual marbling and intramuscular fat content.

(b) Supplementation with protected starch alone, tended to increase intramuscular fat content, but this was not statistically significant ($p>0.05$).

(c) The inclusion of protected nutrients alone or in combination, did not change subcutaneous fat depth. There was a trend towards an increase in hot dressed carcass weight, but this was not statistically significant.

(d) Visual assessment of carcasses tended to underestimate marbling scores when compared to the amount of intra-muscular fat measured by chemical extraction. This discrepancy is due to the very soft nature of the fat in the cattle.

(e) The soft nature of the fat in all cattle was due to the relatively high proportions of unsaturated fatty acids (C18:1; C16:1) and lower proportions of saturated fatty acids (C16:0; C18:0). These fatty acid profiles were influenced by the interaction between genotype and diet. The very low proportions of stearic acid (C18:0) is indicative of an active Δ 9 desaturase enzyme system and warrants further investigation.

(f) The ratio of unsaturated to saturated fatty acids was greater than 1.7 which is indicative of fat with a melting point of less than 30^{0}C.

(g) The mean melting points of subcutaneous fat of 17 cattle from each group were less than 30^{0}C and the inclusion of the protected nutrients made the fat softer.

(h) The softer fat has important implications in respect of influencing the visual marbling assessment and bone-out procedures. Softer fat would enable meat processors to bone out at lower temperatures and thus improve meat safety.

(i) Under the conditions of this experiment ultrasound-scanning results did not accurately predict marble score or percent intramuscular fat. Sequential scanning of the cattle did not result in any improvement in the ability to predict marble score.

(j) Economic analysis of the data showed that under the conditions of the trial the protected starch was the most profitable treatment. However if the costs of the Marble Plus^{TM} treatment could be reduced by even 5% (eg by introducing the Marble Plus^{TM} later in the feeding period) then large increases in profitability could be made.

(k) A cost/benefit study showed that the returns from additional research on the timing of Marble Plus^{TM} feeding could be as high as $10.27 for every research dollar spent and represent a value to the industry of $9.27 million.

6. Recommendations

We have shown that Marble Plus^{TM} significantly increased marbling in beef cattle when fed for 156 to 190 days. The profitability of feeding Marble Plus^{TM} was less than that for the control ration. Use of protected starch was able to increase profitability above that of the control even though it did not significantly increase marbling. We recommend that a further study be conducted to determine the period required to feed the combination of protected lipid, protein and starch (Marble Plus^{TM}) to maximise marbling and profit and to clarify the physiological and biochemical mechanisms involved in response to protected nutrients. That the use of protected nutrients is considered a viable option for increasing meat safety by allowing chillers to be maintained at lower temperatures.

7. Success in achieving objectives

This study provided information on the effects of feeding protected nutrients to feedlot cattle on performance and carcass quality. Economic analysis of the data showed that use of protected nutrients has the potential to increase financial returns to lot feeding enterprises. The objective of the study was achieved. In addition, information was obtained on the use of sequential ultrasound scanning as a means of predicting the marbling performance of cattle being fed in a feedlot situation.

8. Impact on meat and livestock industry

The ability to consistently produce highly marbled beef cattle has huge financial implications for lot feeding enterprises. The use of protected nutrients has the potential to increase the supply and consistency of marbled beef to meet the market demand for a consistent supply of marbled beef. Use of protected nutrients may also allow cattle to be on feed for a shorter period and still obtain the required amount of marbling. Inclusion of protected nutrients into feedlot rations may help to improve meat safety by increasing the ease of boning out carcasses at lower temperatures due to the lower melting point of the fat. Increased levels of unsaturated fats may also have a positive impact on human health.

9. Total funding and MLA contribution

Meat & Livestock Australia Ltd provided funding totalling $31,016. In addition, Department of Natural Resources and Environment provided financial support totalling approximately $46,569 and Rumentek Industries Pty Ltd provided approximately $146,149.

10. Acknowledgments

We are grateful to Rumentek Industries for the provision of the protected nutrient supplements and their support for the study, Ms Eva Fleck of CSIRO Animal Production for the chemical analysis, Mr Owen Laws of EOI Foods Pty Ltd for the melting point estimations. The feedlot staff, Mr John Cook, Mr David Cooper, and Mr Max Fuge, are specially thanked for feeding and managing the steers. The prediction of IMF% from ultrasound images was performed using the Iowa State University USOFT (TM) system as provided to the Animal Genetics and Breeding Unit under the research license agreement. Images were courteously analysed by AGBU. We are grateful to Mr David Goldsworthy for the economic analysis and the cost /benefit analysis of the project.

11. References

AMLC, 1986. 'Handbook of Australian Meat.' (Australian Meat and Livestock Corporation: Sydney.)

AOAC (1997). Official Methods of Analysis 16th edition. Editor: P. Cunniff. Official Methods of Analysis of AOAC, Washington DC

Ashes, J.R., Thompson, R.H., Gulati, S.K., Brown, G.H., Scott,T.W., Rich, A.C. and Rich, J.C. (1993). A comparison of fatty acid profiles and carcass characteristics of feedlot steers fed canola seed and sunflower seed meal supplements protected from metabolism in the rumen. *Aust. J.Agric Res.* **44**: 1103

Christie, W. C. 1989. Gas chromatography and lipids - a practical guide. pp. 66-70. (The Oily Press: Ayr, Scotland).

Genstat 5 Committee (1993). Genstat 5, Release 3 Reference Manual. Clareden Press Oxford.

Gulati, S.K., Ashes, J.R., Scott, T.W., Rich, A.C. and Rich, J.C. (1995). Effect of feeding protected lipids on the chemical and physical structure of lotfed beef fat. *41st International Congress of Meat Science and Technology*, San Antonio, Texas, USA. **2**:A52

Pethick, D, McIntyre, B, Tudor, G and Tume R, (1997). The effect of different cereal grains on marbling and soft fat. *Meat Research Corporation report No. UMUR.004.*

APPENDIX 1:

Economic Analysis of the Feed Additive Project

ECONOMIC ANALYSIS OF THE FEED ADDITIVE PROJECT

Background

This analysis is about comparing the economic returns of a number of treatments applied to cattle in feedlots to increase intra muscle marbling for cattle for the Japanese beef market. The rationale for the research and the various treatments is described in the paper.

Assumptions

In order to ensure an accurate comparative analysis all values (both expenditure and revenue) for the four different treatments were converted to dollars/head. Costs for each treatment were identified as a cost per head.

Results

A cost benefit analysis was requested to analyse this piece of work. However, a simple budget framework is sufficient at this stage to indicate the relative profitability of the four regimes undertaken.

Financial Results

Group	Number	Value in $/Hd[1]	Value out $/Hd[2]	Treatment cost[3] $/hd	Value out less costs[4]	Net Return[5]
Control	50	630.00	1,271	349	**922**	292.00
Marble Plus	53	632.50	1,382	462	**920**	287.50
M+2	51	627.50	1,315	499	**816**	188.50
Starch	51	637.50	1,325	358	**967**	330.00

Notes:

1 Cattle purchase price was $1.25/kg/lw. The cattle in each treatment were of uniform body weight ranging from 502kg – 508 kg. Prices converted to $/hd
Animals were assessed on a HSCW basis and prices paid on a c/kg/HSCW basis.

2 These prices were converted to a dollar a head. It is assumed that these prices are net of killing and marketing costs. No account was taken of any hide value these were probably absorbed in slaughtering charges.

3 These are the average costs per head across all treatments.

4 These are the average prices attained for each group less treatment costs and the most useful numbers to compare treatments.

5 These are the average prices for each treatment and reflect the net return after accounting for the purchase price of the original stock and deducting all treatment costs; the bottom line for the owner of the livestock.

All treatments added value to the finished product. However, in all treatments the cost of value adding exceeded benefits. The most profitable group was the starch.

Treatment M1+ and the control treatments were only marginally less profitable than the control.

Further Research

It is understood that the research scientists are confident that further manipulation of treatments could generate similar increases in marbling at significantly lower cost. If this were possible there could be significant gains to the Japanese B3 segment of the feed lot industry.

One such scenario is if protected starch was fed for the first part of the feeding period followed by Marble Plus treatment for the last 80 days of feed. This would reduce the cost of the Marble Plus treatment by 12%. The following table indicates the possible returns that could be achieved if the treatment cost was reduced by 5, 10 or 15%.

Financial results if treatment cost for Marble Plus was reduced by 5, 10 or 15%

Group	Number	Value in $/Hd[1]	Value out $/Hd[2]	Treatment cost[3]$/hd	Value out less costs[4]	Net Return[5]
Control	50	630.00	1,271	349	**922**	292.00
M +	53	632.50	1,382	462	**920**	287.50
M + (5%)	53	632.50	1,382	439	**943**	310.50
M + (10%)	53	632.50	1,382	499	**966**	333.50
M + (15%)	53	632.50	1,382	393	**989**	356.50

David Goldsworthy

Principal Economist

Economics Branch, NRE

APPENDIX 2:

Cost / Benefit Analysis of Rumentek Project

COST/BENEFIT ANALYSIS OF RUMENTEK PROJECT

Background

This project is aimed at evaluating a proprietary feed additive designed to increase the intra muscle fat marbling in ox destined for the Japanese market. Previous research (Davis et al 1999) has demonstrated that this is achievable and that there is a price premium of $21 a head for additional marbling. However, the price benefits attained were absorbed by the additional costs involved.

Researchers are confident that with further manipulation of feed inputs these costs can be reduced by 12%.

Using the Department of Agriculture's cost/benefit spreadsheet "Appraisal" estimates were made of the of the impact of a using the feed additive and reducing other feed costs by 5%, 10% and 15% respectively.

Assumptions

Investing now rather than later brings forward the benefits of research. This is particularly so with applied research. This is accounted for in the "with and without" concept embodied in the APPRAISAL model. The "with" scenario indicates the return from the research by investing now rather than at a later date. The without scenario is based on the principle that even without the investment now, the benefits from a particular piece of work (or similar) action will flow through at a later date. While based on certain "best guess" assumptions the without scenario tends to give a more realistic result than assuming a one off outcome for which there are no substitutes and which generates benefits ad infinitum.

The Rumentek product is a case in point. The science in this area is well advanced and there are probably a number of products in the pipeline that may be substitutes in the future.

For this reason a conservative approach has been taken to estimating benefits. Nevertheless, at all levels a positive outcome is forecast.

Research Costs

All research costs have been included in the project along with feedlot costs including additional feed costs associated with the product. Not included are earlier costs associated with the development of the product at an early stage.

Benefits

The target group is specifically the premium market for bullocks to the Japanese export market. It has been assumed that a market size of some 150,000 head per annum. As the results of earlier research it is assumed that with cost reductions at the 5%, 10% and 15% levels the premium per head net of costs at 180 days on feed would be, $21, $44, and $67 respectively.

Adoption

As the research is at an advanced stage (validation trials) it is assumed that results will be known within two years and that by year three adoption will commence. Because there are no significant additional cost barriers to adoption (apart from product price) and no complexities in implementation, it is assumed a 90% adoption of the additive by industry.

It is also assumed that full adoption will occur by year 5.

Probability of Success

Probability of success represents the confidence that a successful out come will be achieved.

Results

At a cost reduction of 5% on the original research the benefit/cost ratio is 3.22 with an NPV of $2.22 million.

At a cost reduction of 10% on the original research the benefit/cost ratio is 6.74 with an NPV of $5.74 million.

At a cost reduction of 15% the Benefit /Cost Ratio is 10.27 with an NPV of $9.27 million.

David Goldsworthy

Principal Economist

Economics Branch, NRE