final report

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DEVELOPMENT OF AN OPTIMUM PRODUCTION SYSTEM FOR AUSTRALIAN GRAIN-FED QUALITY BEEF FOR THE JAPANESE MARKET

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FINAL REPORT

PART 1 - Abstract

The CSIRO Meat Research Laboratory at Cannon Hill in Brisbane has undertaken a project funded by the AMLRDC to look at ways to improve marbling in beef for the Japanese market.

The first part of the project was to ascertain whether there was any credence in the belief, that some breeds marble better than others. Samples from over 2000 head of cattle were taken, providing information about marbling, moisture and fat content of the meat. Statistical analysis of these data has shown that no particular breed has any greater ability to marble than any other. However, there is evidence that particular feedlots have been able to cause some breeds to marble marginally better than other breeds. The data base created by this part of the project contains up to sixteen different parameters on most of the animals. It is envisaged that this data base will be built on in the future to provide valuable information to the beef industry.

A trial was conducted at a feedlot in SE Queensland on the affects of protected lipid and protected protein on marbling and fat deposition. Two hundred and forty animals were split into four groups for this trial. Group 1 was the control group and fed on normal feedlot rations. Group 2 and 3 had their ration supplemented with formaldehyde-protected lipid and protein, respectively, and the ration for group 4 contained a combination of both. The trial was conducted over a period of 190 days in order to bring the animals to commercial weights.

There was no effect on the marbling scores in any group, but there was an effect on the subcutaneous fat thickness and on the fat colour in the group which was supplemented with protected lipid.

In the final part of the project effects of short or long term feeding on fat deposition and marbling were determined. At another feedlot in SE Queensland, 120 cattle were allocated to three groups. Group 1 was fed a high protein diet over 202 days, group 2 was on normal feedlot ration for 287 days and group 3 was fed a low protein diet for 307 days.

Adjusting feed ratios, by reducing or increasing protein concentrations, did not have any affect on carcass quality or composition. Marbling score and subcutaneous fat thickness did not differ significantly between groups.

Supplementation of feed with lipid and protein of the type used did not result in expected changes in carcass composition. It would appear that identification and selection of animals with the propensity to produce carcasses of the required characteristics would be a better option than diet manipulation. Similarly, longer or shorter feeding periods, with reduced or increased protein, also had little effect.

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PART 2 - Executive Summary

(i) Background and industry context

The Japanese market for Australian beef has expanded rapidly and is likely to increase even further with liberalisation in 1991. This is creating pressure for the Australian industry to supply the highly marbled, high quality product this market demands. At present Australia is supplying about 56 percent of the bottom 21 percent of the Japanese market, 16 percent of the middle 66 percent of the Japanese market and only 2 percent of the top end of the market, which is largely the province of the Japanese farmers. The potential for improvement and expansion amounts to > $100 million for the Australian Beef Industry. Hence, the rapid expansion of feedlots and recent establishment of Japanese consortia in the Australian industry.

Marbling is primarily a genetic trait of cattle which is capable of nutritional/metabolic manipulation. It has been shown that the various fat depots of cattle utilise different proportions of substrates to synthesise lipid through lipogenesis, eg. subcutaneous fat utilises mainly acetate and little glucose but intramuscular fat utilises largely glucose and little acetate. Furthermore, intramuscular fat accumulates long chain fatty acids for lipid synthesis to a much greater extent than does subcutaneous fat. For these reasons manipulation of the diet may have some potential to increase marbling (intramuscular fat) without creating excess subcutaneous or seam fat deposition.

Feeding a "protected feedlot supplement" to feedlot cattle and, thus, increasing the levels of, rumen bypass, long-chain fatty acids reaching the small intestine for adsorption, could have the potential to increase marbling. Glucose supply from both "bypass grain" and high rumen propionate levels, should be high on the largely high grain based diets fed to feedlot cattle. Preliminary experiments on small numbers of cattle (University of Queensland) indicated a potential for improving marbling by feeding protected lipid (PRIME). A large field trial of PRIME, at ICM Feedlot was not disappointing, but the trial had its complications and the level of protein in the diet was low. This low amino acid supply probably was rate-limiting in terms of a further response in marbling from the increased supply of long-chain fatty acids.

(ii) Objectives

The objectives of this project were:

1. To survey genotypes for their propensity to marble.

2. To manipulate through the use of protected protein and protected fat additives, marbling and fat deposition.

3. By the use of feed growth/rate studies investigate these effects on marbling and fat deposition.

(iii) Brief methodology

Objective 1

A survey of over two thousand head of cattle was done in order to assess the ability of certain breeds to produce marbled meat. Seven feedlots in South-East Queensland agreed to participate in this survey. They agreed to inform us each time that cattle were sent from their feedlots to the abattoir. Our representative would then collect a sample from each carcass. The sample was taken from the 5th/6th rib end of the cube roll (longissimus dorsi). Samples from each group of cattle were boxed, frozen and transported to the CSIRO Meat Research laboratory for assessment of marbling score, moisture and fat. The results were then tabulated and stored in a data base for future statistical analysis.

At the point of collection, as much data as possible was gathered about each individual animal (ie. breed, carcass weight, carcass quality, place of origin, age etc). Up to sixteen variables were measured on most samples.

Objective 2

The trial was a 2x2 factorial with sixty animals per cell. The treatments were:

A. Basal Diet (12% crude protein) + roughage.
B. Basal Diet + 8% protected protein (NORCO) + roughage.
C. Basal Diet + 5% protected lipid (PRIME) + roughage.
D. Basal Diet + 8% protected protein (NORCO) + 5% protected lipid (PRIME) + roughage.

Care was taken that the grain portion of the basal diet was reduced when protected protein was added so that the overall protein content of the ration remained the same (approximately 12-13%).

The additives were thoroughly mixed prior to dispersion into the feed troughs and roughage was supplied ad lib.

The protected fat component was a product called PRIME which was supplied by UNICHEMA. PRIME is a protected tallow consisting of hydrolysed animal fat (99% min) and antioxidant (500 mg/kg). Information from previous trials indicated that 50% of PRIME intake

is partitioned to body tissue, and so may improve intramuscular fat deposition.

The protected protein component was supplied by NORCO. The product name is NOR-PRO. It consists of:

MIN% crude protein	30%
MIN% crude fat	2%
MIN% crude fibre	22%

NOR-PRO is manufactured from high protein sunflower meal, decorticated, solvent extracted, and protected, with 0.7 g of formaldehyde per 100 g crude protein. The sunflower meal is heated to 115°C for 40 minutes during the extraction process. The lot that was used for this trial was manufactured at Lismore to CSIRO specifications.

A selection of 240 head of cattle were bought from various saleyards. They were as uniform in breed and weight as possible. These animals were then randomly distributed into one of four groups. Each group was kept in a separate yard and each yard was designated a colour according to the ear tag colour of each group of animals. The colours allocated to each group were:

A.	PURPLE	-	CONTROL
B.	YELLOW	-	NORCO
C.	WHITE	-	PRIME
D.	BLUE	-	NORCO + PRIME

The starting date, ie. initial weighing/introduction to feed supplements/ear tagging and dehorning was 3rd May 1989.

The beginning of the trial, ie. start of the full ration of feed supplement/weighing and P8 measurement, was 6th June 1989. The other weighing days and P8 measurements were 22 August 1989 and 29 November 1989.

Fat depth, over the P8 site (Moon 1980) was measured using an ALOKA 210D Ultrasound Scanner with a 3.5 MHz transducer. The operator was a member of staff with the LMAQ who had been trained in the use of ultrasound equipment.

The animals were slaughtered on the 10th, 11th, and 18th of December 1989 and the samples were collected on the 12th, 13th and 19th of December. Those animals slaughtered on the 11th of December had been on feed for 189 days, 12th December for 190 days and the 18th of December for 196 days.

All the animals were slaughtered and boned out by the Kilcoy Pastoral Company Pty Ltd at their Kilcoy works. Cube rolls were removed under normal commercial operating conditions. Slices of approximately 0.5 to 1 cm thickness were taken from each end of the muscles from each side of the carcass. The slices were scored for marbling using the Japanese marbling chips for comparison. All samples were transported and frozen for storage on the day of collection. Prior to analysis

for fat and moisture, the samples were thawed and scored for marbling in the laboratory using the Japanese marbling chips.

Objective 3

A selection of 120 head of cattle were bought for the trial. These animals were as uniform in weight and breed as possible under commercial conditions.

The animals were divided into three groups of 40 animals per group.

Group 1 (white)

This group were fed a diet of grain/roughage (4/1), for a period of 150 days in order to produce a predicted growth rate of 1.4 kg/day.

Group 2 (blue)

This group were fed a diet of grain/roughage (1/1), for a period of 200 days in order to produce a predicted growth rate of 1.05 kg/day.

Group 3 (orange)

This group were fed a diet of grain/roughage (1/4), for a period of 250 days in order to produce a predicted growth rate of 0.84 kg/day. All animals were fed with commercial food constituents under normal feedlot conditions.

Liveweight and fat depth were monitored regularly.

The trial began on the 23 August 1989. Prior to these first weighings, the cattle had been divided into three random groups and fed a normal feedlot diet during a settling in period. The animals had been dehorned and eartagged for individual and group identification. Further weighings and ultrasound scanning of all groups were carried out on the 3rd November and the 2nd February.

Group 1 (white) were slaughtered on the 13th March after a period of 202 days.

Group 2 (blue) and Group 3 (orange) were weighed and ultrasound scanned on the 23rd May.

Group 2 (blue) were slaughtered on the 6th June after a period of 287 days.

Group 3 (orange) were slaughtered on the 26th June after a period of 307 days.

The times of slaughter vary from the original protocol due to the fact that this feedlot is a commercial operation and so would not release the cattle for slaughter until they had reached a profitable carcass weight.

At the end of each group feeding period, the animals were slaughtered and boned out by the Kilcoy Pastoral Company Pty Ltd at their Kilcoy works. The cube rolls were removed under normal commercial operating conditions, this being the longissimus dorsi muscle cut from between the 5/6th rib and the 10/11th rib. Slices of approximately 0.5 to 1 cm thickness were taken from each end of the muscles from each side of the carcass. The slices were scored for marbling using the Japanese scoring chips for comparison. All samples were transported and frozen for storage on the day of collection.

All results were then tabulated and the data stored in a data base for statistical analysis.

(iv) Main results and conclusions

Objective 1

Analyses of variance isolated the main effects of breed and feedlot and their interaction. The 54 recorded breeds were amalgamated into the four major breeds:- Hereford, Angus, Murray Grey and Santa Gertrudis, together with four composite breed groups of Shorthorn cross, Bos indicus cross, Angus cross and "others". The four major breeds consisted 71% of the total surveyed.

Analyses of variance for the four major breeds gave similar results to those for the eight breed groups, so that only the latter have been used for interpretation. The interaction of breed group with feedlot was significant for all variables indicating inconsistent breed differences across the seven feedlots. Generally, the main effects had F values much higher than for the interaction, so that the major differences indicated for breed effects were real with the inconsistency being minor by comparison.

Correlations among the variables have been done separately for each of the four major breeds. The correlations were generally consistent across breeds in both size and level of significance. The exceptions were those between Hot Standard Carcass Weight (HSCW) and Fat Colour, HSCW and intramuscular fat% and P8 and intramuscular fat%. The various measures of marbling were quite well correlated.

There is a correlation between HSCW and P8; see the overall correlation table (Table 1). There is a relationship between HSCW and all marbling scores. They are all low but still significant. One surprising feature of the table is that, the expectation of a negative correlation between HSCW and fat colour did not occur with all breeds. Table 2 shows that with Murray Grey and Santa Gertrudis, even though they were at market weight, they still had significant fat colour. It is surprising as it would be anticipated that cattle grown for the same time under feedlot conditions would tend towards a similar fat colour. This suggests that Murray Grey and Santa Gertrudis were heavy and had yellow fat when introduced to the feedlot and put on intermuscular fat at a slower rate than the Hereford and Angus or, that these breeds inherently have yellower fat; there is no evidence for this in the literature. Neither the

origins nor the initial liveweights of these animals were known to us.

The laboratory marbling score was better correlated with intramuscular fat. The abattoir marbling scores (marbling 5 and marbling 10) seem to have been significantly influenced by the fat colour whereas the laboratory score was not. This may have been because the scoring done under abattoir conditions was affected by the type of lighting used (scoring done in the laboratory was done under natural light) or because abattoir assessors biased their marbling scores against animals with yellower fat, or because laboratory scores were based on more assessments per carcass than those at the abattoirs.

As sometimes occurs with these types of surveys, there are more questions created than are answered. The data base we have is a good start at looking at animals fed for the Japanese market. However, it is now obvious that in order to gain a truer knowledge about these animals, we will need to know a lot more about the animal prior to purchase by a feedlot. We will need to know the weight at which the animal was purchased and placed on feedlot rations, the type of feed that the animal has come off and something about its genetics. In this regard, feedlot three appeared different from the others, as the relationship between HSCW and fat colour of animals from this source was very different from other feedlots (see Fig 1).

Objective 2

The daily intakes of each pen are shown in Figs 2 to 5. A summary of feed intake, weight gain and feed conversion is presented in Table 5, which indicates that feed intake was reduced by supplementation. However, as individual feed intakes were not available, no statistical analysis of this data is presented. Weight gains were similar (1.25 to 1.29 kg/day) in all treatments, so feed conversion was improved by supplementation. The changes in both liveweight and P8 fat thickness are shown in Table 6. Supplementation with PRIME tended to decrease subcutaneous fat thickness (but feed intake was also decreased). This decline in subcutaneous fat thickness in the animals eating PRIME (and increase in those on NORCO) was confirmed by P8 measurement in the abattoir. These differences were largely significant (see Table 7). Marbling and meat colour scores were not affected by treatment but PRIME reduced fat colour score, ie. the fat was whiter (see Table 7). Marbling score and intramuscular fat were higher at the 5th/6th than the 10th/11th ends of the cube roll, but neither were affected by treatment (see Table 8).

Objective 3

The original design of this trial was to achieve three different growth rates (1.40, 1.05 and 0.84 kg/day) for three time periods (150, 200 and 250 days) in order that the animals achieved about the same final liveweight (510 kg; initial weight 300 kg). The actual results achieved were as shown in Tables 11-13.

(v) Recommendations

Some exciting new findings have emerged from these studies.

1. There are differences between breeds in their ability to marble. Surprisingly Hereford cattle performed poorly. There are large differences between feedlots in terms of their ability to produce highly marbled cattle. In this survey the factors that contributed to the differences could not be clearly defined.

2. Feeding higher levels of protected lipid and/or protected protein did not improve marbling.

3. It would appear that slower growth rate does have an effect on marbling.

These findings should be made available to the ALFA organisation and to the industry in general in order that they can be debated and evaluated.

TABLE 1: CORRELATION MATRIX

	P8	MS 5/6 RIB	MS 10/11 RIB	MS LAB	FAT COLOUR	INTRA-MUSCULAR FAT%
Carcass weight	0.350	0.038	0.074	0.123	0.095	0.214
P8		0.108	0.103	0.120	0.051	0.122
Marbling score 5/6 rib			0.553	0.543	-0.201	0.367
Marbling score 10/11 rib				0.400	-0.204	0.254
Marbling score lab					-0.058	0.479
Fat colour						0.142

MS - Marbling score

TABLE 2: CORRELATION MATRIX FOR MAJOR BREEDS FOR THE IMPORTANT VARIABLES

		HEREFORD	ANGUS	MURRAY GREY	SANTA GERTRUDIS
Carcass Wt v	P8	.373**	.477**	.481**	.278**
	Marb 5	.103	.120	-.153*	-.128
	Marb 10	.153	.112	-.114	-.016
	Marb Lab	.005	.099	.046	.044
	Fat Col	-.132	-.001	.465**	.335**
	IM fat %	.011	.131	.432**	.413**
P8 v	Marb 5	.019	.168*	.067	.020
	Marb 10	.091	.132	-.032	.047
	Marb Lab	-.039	.139*	.210**	.172*
	Fat Col	.053	-.036	.180*	-.012
	IM fat %	.082	.054	.351**	.180*
Marb 5 v	Marb 10	.514**	.556**	.526**	.528**
	Marb Lab	.542**	.538**	.533**	.521**
	Fat Col	-.157*	-.287**	-.242**	-.172*
	IM fat %	.513**	.313**	.275**	.200**
Marb 10 v	Marb Lab	.255**	.431**	.374**	.365**
	Fat Col	-.230**	-.234**	-.201**	-.106
	IM fat %	.279**	.230**	.166*	.169*
Marb Lab v	Fat Col	-.112	-.044	-.064	-.032
	IM fat %	.502**	.379**	.485**	.426**
Fat Col v	IM fat %	.102	.126	.262**	.148**

Confidence Limits * = 5%
** = 1%

TABLE 3

BREED	CARCASS WEIGHT	P8(mm)	MS ABATTOIR	MS LAB	INTRA-MUSCULAR FAT%
Hereford	374	31	2.6	3.2	7.4
Angus	372	25	2.9	3.5	8.3
Murray Grey	378	20	2.6	3.5	9.0
Santa Gertrudis	387	21	2.6	3.3	7.3
Shorthorn	389	30	2.8	3.7	8.8
Bos Indicus X	396	25	2.6	3.0	8.0
Angus X	385	24	2.8	3.5	7.9

MS = Marbling score
Carcass P8 measured by probe

Marbling Score Range 1 (lowest) - 12 (highest)

TABLE 4

VARIABLE	BREED	FEEDLOT
HSCW	**	**
P8	***	***
FC5th	***	***
FC10th	***	**
EMA5	NS	**
EMA10	*	***
Marbling 5th	***	***
Marbling 10th	***	***
Marbling Lab	***	***
Fat Colour	**	***
Meat Colour	**	***
Moisture %	***	***
IM Fat %	*	***

Confidence Limits * = 5%
** = 1%
*** = 0.1%

TABLE 5: LIVE ANIMAL DATA

	CONTROL	NORCO	PRIME	PRIME/NORCO	LSD
Feed Intakes (kg/day)	13.8	13.1	12.5	11.9	***
Weight Gain (kg/day)	1.3	1.3	1.3	1.3	0.03
Feed Conv. (kg feed/kg gain)	10.8	10.5	10.2	9.7	0.54

*** Pen data only

TABLE 6: LIVE ANIMAL DATA

	CONTROL	NORCO	PRIME	PRIME/NORCO	LSD
LIVEWEIGHT (kg)					
Initial	466	475	450	442	14.5
Final	693	701	671	662	18.9
Change in weight	227	226	221	220	11.7
P8 FAT THICKNESS (mm)					
Initial	10.2	10.4	8.6	8.7	0.99
Final	23.3	24.9	21.3	20.2	2.25
Change in P8	13.1	14.5	12.7	11.5	1.76

TABLE 7: CARCASS DATA

	CONTROL	NORCO	PRIME	PRIME/NORCO	LSD
HSCW (kg)	375.6	379.6	363.8	357.0	6.96
Abattoir P8 - HGP (mm)	30.9	32.9	29.2	27.9	2.06
Marbling Scores	2.8	2.7	2.7	2.6	0.17
Meat Colour Scores	1.3	1.3	1.2	1.3	0.13
Fat Colour Scores	1.7	1.6	1.3	1.2	0.16

N = 59/group
HGP = Hennessey Grading Probe
Meat Colour Score 1 (light) - 7 (dark)
Fat Colour Score 1 (white) - 7 (yellow)

TABLE 8: LABORATORY MEAT DATA

	CONTROL	NORCO	PRIME	PRIME/NORCO
INTRAMUSCULAR FAT %				
5/ 6th Rib	8.7	8.9	8.1	7.8
10/11th Rib	5.9	5.6	5.6	5.5
MARBLING SCORES				
5/ 6th Rib	2.8	3.0	3.0	2.9
10/11th Rib	2.4	2.4	2.4	2.4

TABLE 9: FATTY ACID ANALYSIS

	SUBCUTANEOUS FAT			
	CONTROL	NORCO	PRIME	PRIME/NORCO
FATTY ACID				
14:0	3.3	2.9	3.3	3.0
14:1	1.2	1.0	1.2	1.0
16:0	26.7	26.5	25.6	25.7
16:1	4.9	4.8	5.1	4.5
17:0	1.0	1.0	1.1	1.2
17:1	0.9	0.8	1.2	1.0
18:0	10.6	10.2	12.3	13.0
18:1	47.3	47.6	44.0	45.2
18:2	1.1	1.4	1.7	1.7
Other	3.0	3.8	4.5	3.7

(% distribution)

TABLE 10: FATTY ACID ANALYSIS

	INTERMUSCULAR FAT			
	CONTROL	NORCO	PRIME	PRIME/NORCO
FATTY ACID				
14:0	3.2	3.2	3.2	3.2
14:1	0.7	0.8	0.7	0.8
16:0	25.8	26.4	26.0	25.6
16:1	3.5	3.7	3.3	3.4
17:0	1.1	1.0	1.4	1.4
17:1	0.6	0.8	0.8	0.8
18:0	15.8	14.6	19.7	19.1
18:1	45.1	42.6	39.8	40.6
18:2	1.2	1.3	1.7	1.5
Other	3.0	5.6	3.4	3.6

(% distribution)

TABLE 11

GROUP	INITIAL WT (kg)	FINAL WT (kg)	GROWTH (kg/day)	DAYS ON FEED	INITIAL FAT DEPTH P8(mm)	FINAL FAT DEPTH P8(mm)
White	419	637	1.34	202	9.1	23.3
Blue	417	682	0.97	287	8.6	23.0
Orange	428	656	0.84	307	10.0	23.8

Initial fat depth P8 measured by ultrasound
Final fat depth P8 measured by ultrasound

TABLE 12

GROUP	MARBLING SCORE 5/6 RIB	IM FAT%	P8 FAT DEPTH (mm)	AVERAGE DAILY GAIN (kg)	FINAL WEIGHT (kg)
White	2.33	5.14	23.3	1.34	637
Blue	2.65	7.06	23.0	0.97	682
Orange	2.51	5.71	22.8	0.84	656
LSD	0.205	1.373	-	-	-

IM = Intramuscular
P8 fat depth measured by ultrasound

TABLE 13

GROUP	HSCW (kg)	CARCASS P8 (mm)	MARBLING SCORE 5/6 RIB	MARBLING SCORE 10/11 RIB	IM FAT %
White	370	32	2.33	1.76	5.14
Blue	380	34	2.65	2.11	7.06
Orange	370	32	2.51	-	5.71
LSD	-	-	0.205	0.217	1.373

IM = Intramuscular
HSCW = Hot standard carcass weight
Carcass P8 measured by probe
Marbling Score 1 (lowest) - 12 (highest)

Fig 2

FEED INTAKES (control)

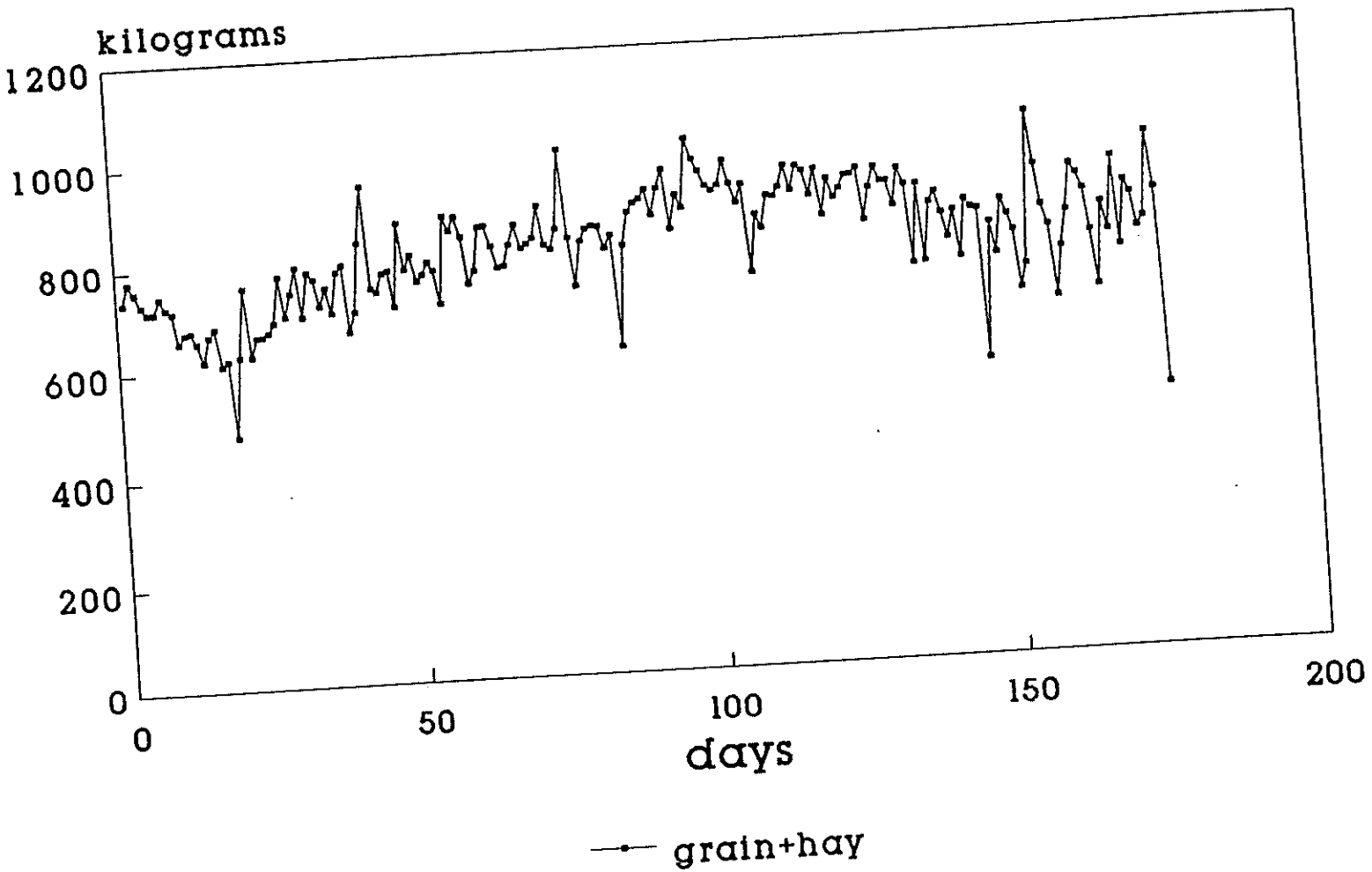

Fig 1

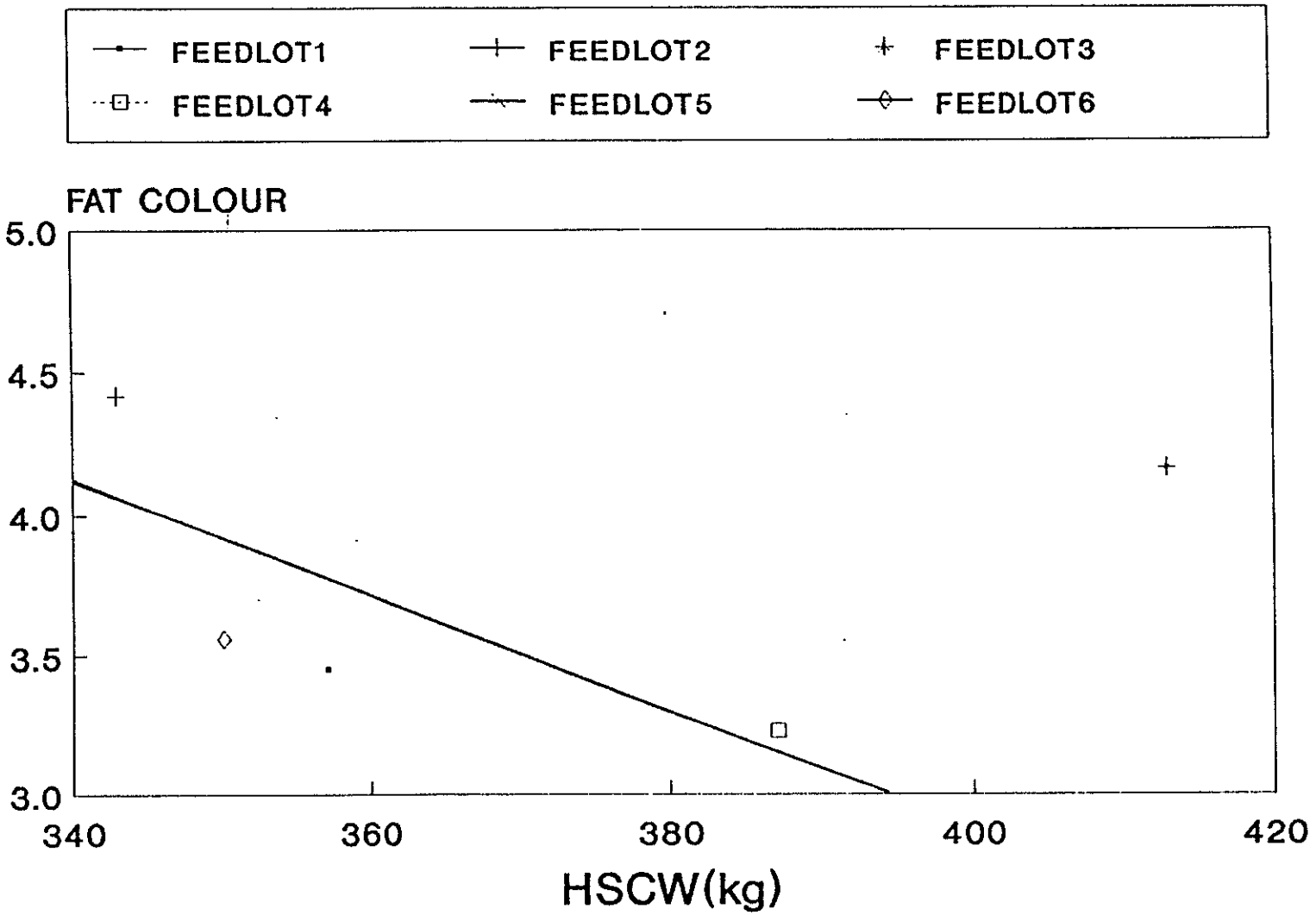
FEEDLOT1
FEEDLOT2
FEEDLOT3
FEEDLOT4
FEEDLOT5
FEEDLOT6
FAT COLOUR
5.0
4.5
4.0
3.5
3.0
340
360
380
400
420
HSCW(kg)

Fig 3

FEED INTAKES (norco)

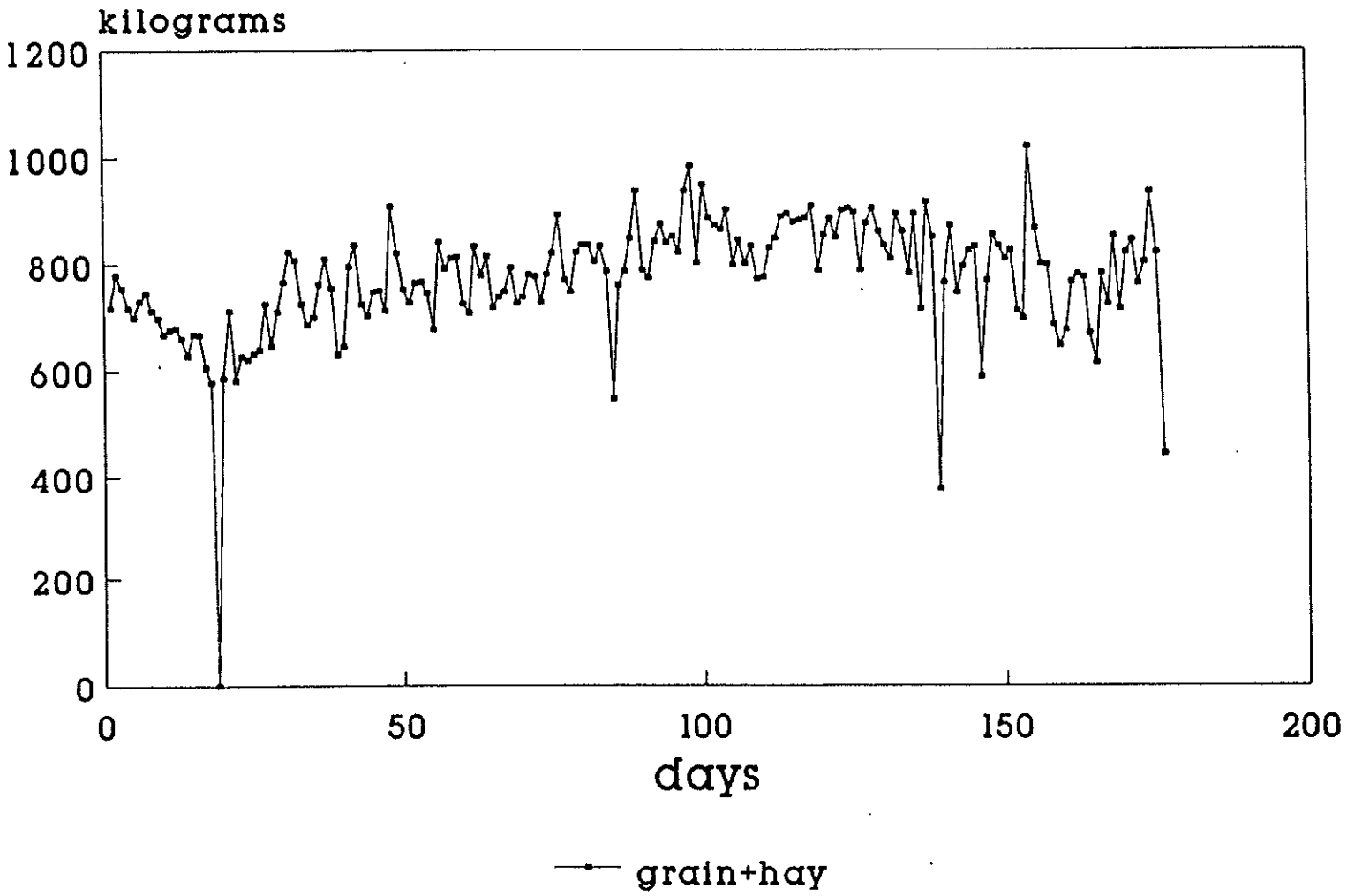

Fig 4

FEED INTAKES (prime)

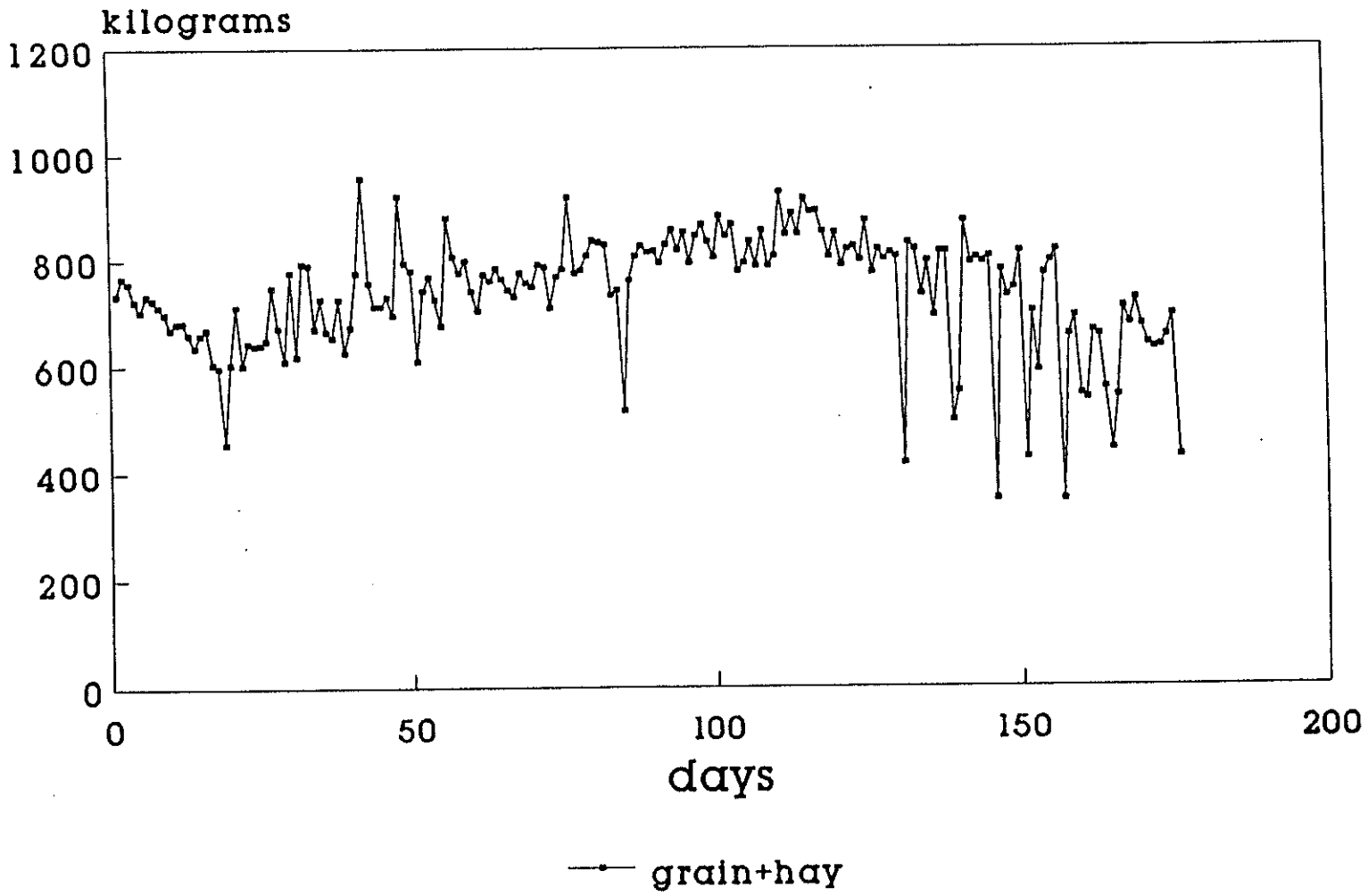

Fig 5

FEED INTAKES (prime/norco)