What Can Australian Nutritionists Offer the Feedlot Industry?

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Summary

The beef cattle feedlot industry is here to stay. Early developments based on largely imported know-how have matured. Australian derived information relating to improving feed conversion efficiency by genetic means, changing growth path, use of alternate feedstuffs, application of new introductory feeding schemes and use of novel pre-boosting technology which integrates immunological, behavioural and nutritional strategies are under development. In addition, the rumen escape technology developed by Australian scientists has come of age and is a powerful tool to manipulate animals to meet specifications for high quality markets. These advances indicate that Australian animal scientists can make a significant contribution to the profitability of our feedlot industry.

Introduction

The Australian beef feedlot industry has developed primarily using the technical skills learned in the feedlot industry of the United States. This has enabled rapid progress in feedlot design, cattle handling, nutritional management and health control, without the trauma of learning from first principles. The industry has now come of age, and with current projections for expansion in both export and domestic markets should become a significant part of the Australian beef industry, and contribute substantially to the Australian economy.

How then will the technical information required by the feedlot industry evolve? In particular what information is available which is presently not fully utilised, but which could be of significant value to the industry, and what is under development. This paper will describe some developments in the broad field of ruminant nutrition which may have a place in the feedlot industry.

Our feedlot industry differs to that of the US in that it has to meet a diverse set of specifications in the live animal to meet the requirements of our different markets (Figure 1). These specifications require different growth rates, and for some markets, nutritional strategies to maximise fat deposition. In each case the objective is to obtain these cattle and meat specifications at the lowest possible cost.

In US feedlots the major determinants of profitability are (in order of decreasing importance) price returned on sale of finished cattle, costs of feeder cattle and cost of feed (Lee, 1993). These important economic (and in part non-biological) elements are justifiably the main concern of the feedlot manager. Nonetheless, there are several biological elements where improvements can be made.

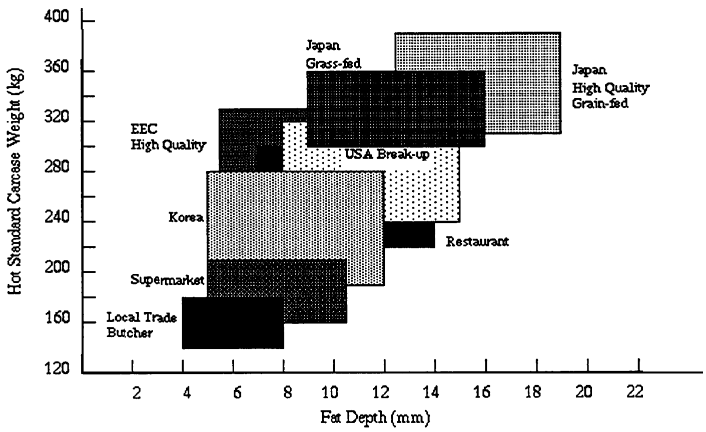


Figure 1 Range of markets, and carcass weight and fat depth specifications, which the Australian beef industry supplies. To meet these markets rquires a wide range of finishing systems using different types of cattle.

Improving Feed Conversion Efficiency

Maximising feed conversion efficiency is arguably the most important area where improvements can be made. Although at any point of time feedlots are locked into feed prices and supply / handling facilities, they can improve returns on finished cattle by reducing costs to reach market specifications. There is a spectrum in efficiency of conversion of feed to animal product which can be shifted to the more efficient end by a variety of methods. The feedlot industry attempts to maximise FCE by using diets which are highly palatable (ie have high intake) and are of high nutrient density to maximise nutrient intake, maximise gain and dilute the costs of maintaining animals. Feed conversion efficiency (FCE, simply described as the amount of feed eaten per unit gain) is subject to both genetic and environmental variation.

Genetic

Studies with lines of sheep and cattle selected for high rates of growth showed there is genetic variation in Net FCE, as has been recognised in the poultry, dairy and pig industries for over a decade. Phenotypic selection of cattle which use less feed to maintain weight and to grow seems to be possible. Early results from an experiment at the Trangie Agricultural Research Centre indicate that individual bulls and heifers from one breed differ by up to 33% in the amount of feed intake used to gain and maintain the same weight between 8 and 12 months of age (Table 1, DAN 075, 1994). Rankings of bulls who produced these offspring indicate approximately 7 to 8% variation between sires (Table 2), indicating that Net FCE is moderately heritable. We do not yet know the physiological adaptations by which some cattle are more efficient than others. It is unlikely to be a single gene. In the selection lines of sheep there are inherited differences in feed intake, feed organic matter digestibility (Herd et al, 1993), nutrient partitioning between muscle and wool, muscle oxygen utilisation, muscle protein degradation, IGF-1 concentration and muscle insulin sensitivity (Oddy , 1993) which together amount to marked differences in growth and FCE. Ultimately, selection using one or several of these traits, if they are also associated with differences in efficiency of cattle, could be used as an indirect tool

Table 1 Best and worst 5 bulls and heifers in a 120 day net feed conversion efficiency test of 200 animals. Cattle were all Trangie Angus 8 - 12 months old, fed *ad-libitum* a pelleted diet of 70% lucerne, 30% grain. Feed intake deviations are used to rank animals. Deviations were calculated from the expected intake for the observed weight and weight gain, negative values indicate animals ate less than expected to achieve their performance.

Tag	Sire	Average daily gain (kg/day)	Final weight (kg)	Expected feed intake (kg)	Actual feed intake (kg)	Feed intake deviations (kg)	Net FCE ranking
(a) Bull calves							
N056	Scotch Cap	1.64	607	1734	1529	-205	1
N078	Scotch Cap	1.38	524	1525	1367	-157	2
N276	Wattletop	0.97	449	1325	1186	-139	3
N080	Ranui Director	1.52	535	1559	1437	-121	4
N055	Millah Murrah	1.34	548	1581	1462	-119	5
N144	Te Mania Herald	1.17	558	1596	1735	139	94
N084	Rambo 465T of JRS	1.45	583	1669	1808	139	95
N281	Pine Creek Mr USA	1.28	493	1446	1616	170	96
N091	Summitcrest Powerplay	1.64	565	1635	1805	170	97
N186	Millah Murrah	1.54	569	1639	1881	242	98
(b) Heifer calves							
N189	Eastern Plains Landmark	1.22	450	1458	1275	-183	1
N212	Wattletop	0.95	430	1355	1225	-130	2
N042	Ranui Director	1.17	469	1490	1388	-103	3
N176	Talooby Kimberly	0.83	390	1237	1136	-100	4
N303	Talooby Kimberly	0.96	376	1231	1151	-80	5
N044	Summitcrest Powerplay	1.06	400	1308	1403	95	92
N289	Pine Creek Mr USA	1.06	420	1355	1466	111	93
N295	Pine Creek Mr USA	1.22	479	1523	1657	134	94
N243	Pine Creek Mr USA	1.01	431	1368	1508	139	95
N068	Rambo 465T of JRS	1.28	463	1502	1643	141	96

Compensatory Gain

Capitalising on compensatory gain during the finishing period is another way to increase FCE. In many studies the impact of compensatory gain on weight gain and FCE is variable. However, there is sufficient evidence to indicate that reduced rates of growth during the pre feedlot period can be exploited during the feedlot finishing period (Table 3). This is not the classic compensatory gain as occurs after the long dry season of Northern Australia, but a more subtle, but nonetheless important characteristic of recovery after moderate rates of gain in otherwise well grown cattle. The bioenergetics of individual animals and the energetic efficiency of gain does not change, but the composition of gain is altered to include more protein and less fat in the immediate period of recovery during refeeding, and feed intake is often increased. Accordingly, FCE is increased. Because composition of compensatory gain is different to that of normal growth, it is important to use this technique within the constraints of the particular target market. Use of compensatory gain has important implications for backgrounding treatments and feedlot entry specifications.

Low cost feedstuffs

The pragmatic approach of defining production efficiency as gain (or output) per $ spent highlights further opportunities. Silages have the potential to provide a low cost but highly productive feed. When combined with on-farm management practises to save feed (as silage) from periods of excess and move it to periods of relative scarcity they play a significant role in improving productivity (Nixon, 1994). High quality silages are effective finishing rations with gains for similar periods comparable to "traditional" high grain feedlot rations (Kaiser, 1993). In these rations the low cost production of high energy silages produce gains at

Table 2 Average performance of sires during the first 120 days of net feed conversion efficiency. Data are from the test described in Table 1.

Sire name	No. of progeny	Average daily gain (kg/day)	Final weight (kg)	Expected feed intake (kg)	Actual feed intake (kg)	Deviation mean (kg)	Deviation range (kg)
Ranui Director	9	1.24	455	1474	1423	-50	43
Scotch Cap	12	1.21	486	1537	1489	-47	38
Wattletop	17	1.03	446	1342	1315	-26	31
MA Commander	11	1.11	441	1424	1405	-19	39
VDAR New Trend	11	1.20	469	1517	1502	-15	40
Mordallup King	13	1.24	444	1451	1437	-14	36
Barwidgee Fortune	8	1.20	431	1404	1397	-7	46
Talooby Kimberly	19	1.04	420	1280	1278	-3	30
Millah Murrah	9	1.21	459	1463	1463	0	43
Eastern Plains Landmark	16	1.09	439	1347	1352	5	33
Pine Creek Mr USA	22	1.14	448	1381	1395	14	28
Te Mania Herald	15	1.27	510	1606	1626	20	34
Summitcrest Powerplay	10	1.19	462	1481	1524	43	41
Rambo 465T of JRS	13	1.25	480	1535	1579	44	36
Innesdale Justice	8	1.13	441	1434	1483	49	46

Table 3 Post weaning nutrition effects on subsequent feedlot and pasture finishing gain. *Bos taurus* weaners (7-8 months, approximately 230 kg) were then grown out under three different pasture management regimes to domestic feedlot entry weight (approximately 300kg), and grown to approximately 400 kg. Data shown are least-square means adjusted for breed and herd of origin effects. Means with different superscripts differ ($P<0.05$). Unpublished data of R. Dicker and D. Robinson.

Grow out treatment between weaning and start of finishing phase	Liveweight gain in the grow out phase (kg/d)	Liveweight gain during finishing phase in feedlot (kg/d)	Liveweight gain during finishing phase at pasture (kg/d)
Improved pasture only	0.52^{a}	1.76^{a}	0.86^{a}
Pasture plus pellets (1 kg/d)	0.51^{a}	1.65^{ab}	0.91^{a}
Pasture plus forage crop (Concorde Ryegrass)	1.01^{b}	1.55^{b}	0.75^{b}

considerably less cost. Intake, weight gain and FCE for yearling cattle finished (carcass range 200-220 kg) on different silage diets with varying proportions of grain added are shown in Table 4. The diets were of varying protein content, but contained enough to meet calculated rumen requirements of cattle (SCA, 1990). The financial advantage of using silage and grains together is shown in Table 5. Clearly the relative cost of silage and grain has a big impact on returns per head. Part of the advantage of the high silage diets is that growth during the first month of cattle being in a feedlot is significantly better than with traditional high grain / low quality roughage feedlot diets (Table 6).

There were no significant effects of silage type, or proportion of grain inclusion on meat or fat colour, marbling score (or intramuscular fat content). Although there was a trend to increased fat content of total 9-11th rib with increasing grain, this was not expressed in marbling score. Meat quality as assessed by pH, cooking loss, Warner-Bratzler peak force (estimate of tenderness) and Instrom compression (an estimate of toughness associated with collagen cross

Table 6 Liveweight gains in the first 30 days, and in the overall (90 day) feeding period, showing the effect of grain proportion on gain in the first 30 days. Unpublished data of A.G. Kaiser.

Silage	Grain %	1st 30 days kg/d	overall kg/d
Sub-clover Silage	0	1.23	1.14
	27	1.27	1.42
	54	1.20	1.34
	80	0.77	1.20
Maize	0	0.80	1.04
	27	0.70	0.96
	54	0.87	1.13
	80	0.50	0.98

Table 4 Performance of steers on silage based diets varying in grain content (Adapted from Kaiser, 1993).

		Proportion of grain in diet (%)				
Silage	**Parameter**	*0*	*27*	*54*	*80*	*sed*
SubClover	*DM Intake (kg/d)*	9.11	10.17	9.14	8.36	0.437
	LWG (kg/d)	1.14	1.42	1.34	1.20	0.100
	FCE	8.13	7.26	6.90	7.06	0.431
Maize	*DM Intake*	7.47	7.43	7.34	6.41	0.437
	LWG	1.04	0.96	1.13	0.98	0.100
	FCE	7.31	7.76	6.50	6.65	0.431
Grain Sorghum	*DM Intake*	8.05	8.40	9.07	8.39	0.491
	LWG	0.91	1.05	1.22	1.23	0.121
	FCE	8.91	8.04	7.50	6.94	0.602

Table 5 Summary of costs and returns for silage based finishing systems where producers finish own steers and use own equipment for silage making (Kaiser, 1993).

	Proportion of grain in diet (%)			
Silage System	*0*	*27*	*54*	*80*
Winter Cereal/Legume				
Costs $ head	101	113	122	125
Net returns $ head	69	60	51	48
Irrigated Maize (Northern NSW)				
Costs $ head	108	125	140	148
Net returns $ head	65	89	33	26

links) was not affected by silage type or grain content of the fmisher ration (Kaiser, 1993). All meat quality measurements were in the high quality range for the domestic market. Although silages can be used as the major constituent in feedlot rations, their use presents logistic problems for feedlots geared up to use traditional forages as roughages. Nonetheless, a high silage system has been implemented in at least one major Australian feedlot.

Smoother introduction to feedlot diets

Another way to improve FCE is to modify introductory rations to ensure both a high energy intake, but avoid complications of acidosis. Callow (1993) investigated use of lupin grain in the introductory ration as a replacement for roughage. Lupins differ from cereal grains in that their storage polysaccharide is predominantly amylopectins rather than starch. Rumen fermentation of lupins does not result in excess lactic acid formation. In the first month liveweight gains were significantly better using lupins than the normal introductory ration (respectively 1.36 v 0.95 kg/d, $P<0.01$). These early gains persisted throughout the 90 d period on feed (1.43 v 1.23 kg/d, $P<0.05$), such that cattle in the lupin treatment groups weighed 15 kg more than the control (normal introductory ration) group, returning an additional $12.00 per head over cattle introduced to grain using the normal feedlot introductory regime.

Because the first month in the feedlot has such an important effect on the adaptation of cattle to grain and the feedlot environment, strategies which improve the capacity of cattle to adapt to the feedlot can improve early gains, reduce morbidity and increase FCE. The pre-boosting methodology currently under development by Drs L. Fell and K. Walker and their colleagues uses a combination of immunological challenge against possible feedlot diseases, behavioural conditioning to yards and close proximity to humans, and nutritional training techniques at weaning. Early results indicate that there are significant advantages in liveweight gains in the first month in the feedlot (Figure 2) and reduced morbidity in the pre-boosted cattle.

Modification of Carcass Composition

Nutritional strategies to modify carcass composition and meat quality specifications can now be employed to maximise returns for finished cattle for markets which require a marbled end product.

Changes in body and carcass composition can be achieved by using dietary additives which allow nutrients, in particular protein (amino acids) and fat, to escape rumen fermentation. Rumentek, is a commercial product developed from a rumen protected protein lipid complex first described over 20 years ago (Scott et al, 1970). In early studies with sheep rumen protected lipids from various sources manufactured using a prototype technique significantly altered the amount and composition of triacyl glycerol fatty acids in all body depots. In recent experiments with feedlot cattle use of protected oilseed enhanced marbling score (Table 7) and altered composition of triacyl glycerol fatty acids.

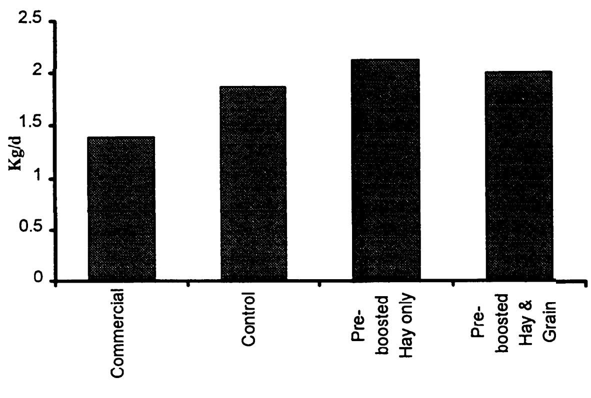
The change in fatty acid composition of subcutaneous adipose tissue induced by feeding protected oilseed (reduction in proportion of saturated fatty acids) was associated with a lower melting point of fat. For example, in cattle eating diets containing protected canola oilseed melting point of fat was 34-35° com-

Table 7 Effect of feeding rumen protected oilseed at 15% of the diet on marbling scores in *Bos indicus* cross cattle lot fed for 150 days. (T. W. Scott, J.R. Ashes, J.C. Rich & S.K. Gulati, pers. comm.)

Marbling Score[1]	**Proportion of cattle in marbling score class %**	
	Control	***Protected oilseed***
1	60	15
2	35	40
3	5	35
>3	0	10

[1] Standard Ausmeat classification, effect of protected oilseed $P<0.001$

Figure 2 Effect of pre-boosting treatments on gain in the first 37 days in a commercial feedlot. The commercial group are cattle from an unknown source mixed into the pen, control group are cattle of the same source as pre-boosted cattle but not treated, pre-boosted cattle were treated as described in the text with nutritional treatments at weaning, some 6 months before feedlot entry, as follows (Hay only - small amount of hay in trough; Hay & Grain - same hay as hay only plus 1kg/day of lupins:oat grain 40:60 w/w). Unpublished data of L.R. Fell.



pared to 39-40° in cattle fed normal feedlot diets (T.W. Scott, J.R. Ashes, J.C. Rich & S.K. Gulati pers. comm.). A lower melting point of fat, resulting from decreases in proportion of saturated fatty acids in cattle fed protected oilseed, is important in the boning room, where hard fat increases the amount of time required to reduce a carcass to primal and retail cuts.

Conclusions

In addition to the information briefly presented above, there are a wide range of research and development activities presently underway in Australia which have the potential to significantly benefit the beef cattle feedlot industry. Included in these are techniques to reduce the impact of acidosis on performance of feedlot cattle, alternate methods to protect fats from rumen fermentation, and technology to optimise microbial protein production in the rumen and thus save on expensive protected protein sources. These advances indicate that there is much that Australian nutritionists can offer the feedlot industry.

Acknowledgments

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