Response in Beef Cattle to Concentrate Feeding in Winter

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SUMMARY

Any discussion on concentrate feeding levels in winter must be in the context of an overall production system. This is particularly so nowadays with premia and other agri-environmental payments contributing so much of the profit margin. Thus, production systems must be designed to maximise the draw-down of direct payments, and feeding levels must then be designed to deliver these production systems.

Weanlings

- For most production systems the target weight gain for weanlings in winter is 0.5 to 0.6 kg/day. In most normal situations there is no need for a concentrate protein level higher than that found in barley.
- Data indicate that the optimum economic concentrate level for feeding to weanlings is less than 1.5kg/day. Even at 1.5kg/day, the cost of concentrates can be greater than the value of the extra carcass production.
- While the immediate response to concentrates is similar for both light and heavy weanlings, the light animals retain more of the response to slaughter. Thus, higher levels of concentrates are warranted (and in any event are generally necessary to meet system targets) for light weanlings.
- Valuing liveweight at £1.00/kg, it is profitable to feed 1.0kg/day up to a concentrate price of £160/t. Only when concentrates are less than £120/t is up to 2.0kg/day justified and more than 2.0kg/day is never justified.

Stores

- The optimum level of concentrate supplementation for store cattle in winter is in the range 0 to 1.0kg/day. For practical purposes, the general recommendation is to feed none, but where silage is scarce or quality poor, feeding up to 1.0kg/day concentrates will cover its costs.

Finishing cattle

Heifers

- As concentrate costs increase, less concentrates can be economically justified (ignoring other factors such as system

requirements and direct payments). In general, up to 4.0kg/day concentrates can be fed when concentrate costs do not exceed £160/t. At £140/t, up to 5.0kg/day can be fed while 6.0kg/day can be fed if concentrates are only £120/t. Below £100/t, concentrates can be fed *ad libitum*.

Steers

- If carcass is valued at around £2.00/kg then when concentrates cost £160/t, no more than 4.0kg/day can be justified economically. As concentrate price falls the level of supplementation can increase. At £140/t, 6.0kg/day can be fed, at £120/t, 8.0kg can be fed and below £100/t, concentrates can be fed *ad libitum*. In brief, the economic optimum level of concentrate supplementation for finishing steers varies by about 1.0kg/day per £10/t change in concentrate price.

Duration of feeding period

Animal performance can vary considerably over the winter. During a typical (147 days) finishing period the performance over the first 8 weeks for steers fed silage only may be 0.8 kg/day while those fed 6.0kg/day supplementary concentrates may gain up to 1.4 kg/day. Over the next 6 weeks these values can drop to 0.6 kg/day and 1.0 kg/day for the silage only and the silage plus concentrates respectively. Further drops to 0.5 kg/day and 0.8 kg/day can be expected over the final 7 weeks. Thus, the mean values of 0.7kg and 1.1 kg/day for silage only and silage plus concentrates are comprised of quite high values in the early part, and much lower values in the latter part, of the finishing period.

Pattern of concentrate supplementation

A number of experiments have been carried out where flat rate feeding was compared with modulated feeding. Over a 126 day finishing period, animals were fed either a flat rate of 5.0kg/day concentrates throughout, or were fed the same target total concentrate allowance in an increasing incremental manner (i.e. 2.5, 5.0 and 7.5kg/day for the 1st, 2nd and 3rd one-thirds of the finishing period) or fed *ad libitum* over the final half of the finishing period. The pattern of concentrate supplementation did not affect performance or efficiency but higher concentrate levels towards the end of the finishing period reduced carcass fatness.

Finishing on high concentrate diets

Barley beef

- In Ireland, both calves and concentrates are relatively expensive, so profit margins from such a system are generally low or negative. When calves are expensive and concentrates are cheap the optimum slaughter weight is high, whereas when calves are cheap and concentrates are expensive the optimum slaughter weight is lower.
- Friesian bull calves can be conventionally reared to about 3 months of age, then placed on *ad libitum* concentrates (plus a small quantity of roughage to maintain rumen function) until slaughter about 9 months later. Average daily gain is higher in the first 6 months (1.3kg/day) than during the final 3 months (1.1kg) with an overall average of about 1.25kg/day. A carcass gain of 0.7kg/day and a feed to carcass ratio of 10.1 can be expected. A 250kg carcass can beproduced from this system starting with a 3-month-old reared calf, and a feed input of just over 2.0 t concentrates.
- At concentrate and calf prices of £130/t and £140, respectively, and a carcass price of £2.00/kg, there is a margin of about £100 per animal available to cover all other costs and leave a profit. This system will have little application in Ireland so long as the possibility of calf exports keep calf prices high and concentrates remain expensive.

Young bulls

- A type of animal commonly available is early born Holstein/Friesians which have spent their first summer at grass and are fairly well grown. Such animals may be fed on *ad libitum* concentrates for 6 to 9 months. A daily gain over the first 6 months of about 1.4kg/day can be expected falling to 1.2kg/day afterwards. Slaughter weight is about 550kg after 6 months or 670kg after 9 months. Concentrate consumption is about 1.8t for 6 months and 3.0t for 9 months.
- Valuing concentrates and silage at £140/t and £15/t, respectively, gives total feed costs of about £260 for 6 months. Valuing the weanling at £250 brings the total costs of animal plus feed to £550. At a carcass weight of 300kg and a value of £2.00/kg, this leaves a margin of £50 plus the bull premium, the slaughter premium and any other direct payments for which the animal is eligible.

Finishing heifers

- Generally, heifers do not have the same potential to benefit from high energy feeding as bulls and they can be readily finished on cheaper feeds. Nevertheless, heifers of high growth potential (e.g. continentals and animals with potential for compensatory growth) can sometimes be profitably finished on all concentrate diets.
- Continental cross heifers finished on all concentrates consume about 10kg concentrates per day in addition to a small quantity of silage. A daily liveweight gains of 1.3kg and a daily carcass gain of 0.8kg can be expected.

Finishing steers

- Charolais x steers of approximately 500kg initial liveweight were fed on concentrates *ad libitum* for 12 or 23 weeks before slaughter. For the first 12 weeks, liveweight gains of 1.4kg/day and carcass gains of 1.0kg/day were achieved. Concentrate intake was about 12kg/day giving a feed conversion to liveweight gain ratio of about 8.5:1 and a feed conversion to carcass gain ratio of about 11.5:1. Over the next 11 weeks, liveweight gain declined by nearly 0.3kg/day and carcass gain declined by nearly 0.2kg/day, but concentrate intake increased by over 1.0kg/day. Accordingly, efficiency of conversion of feed to liveweight and carcass gains declined by almost 40%. These data clearly indicate that where high concentrate feeding is practised the feeding period should be as short as possible consistent with producing an acceptable carcass.
- In terms of carcass traits, most of the benefits in kill-out and conformation had been obtained by 12 weeks with little further improvement (and deterioration in fatness) thereafter.
- If the initial cost of the cattle exceeds £1.00/kg liveweight, then it is difficult to make a worthwhile margin unless there is a sizeable carcass premium or concentrates are cheap.
- Most experiments on high concentrate feeding have been based on barley because of its consistent quality but similar results have been obtained with other feeds. All the pulp-based rations were similar to a barley-based ration.
- In a comparison of barley and gluten, as the proportion of gluten in the diet increased, intake increased and was 14% higher for all gluten than for all barley. Liveweight gain was similar for all treatments but efficiency was poorer for the gluten. It was estimated

that the relative energy value of gluten was 86% that of barley for high concentrate finishing.
- In a "barley beef" experiment, barley and maize were compared over an 8 month feeding period and no differences were observed in feed intake or daily gain. Neither were there any differences in slaughter or carcass traits.

In conclusion, high concentrate finishing is simple to operate and the results are predictable. A wide range of feeds can be used including cheap pulps and by-products of high quality. Within limits, animals will adjust their intake to the quality of the feed and thereby maintain a high level of performance. All else being equal, high concentrate finishing results in carcasses which are somewhat less fat than those conventionally finished on silage plus concentrates. Nevertheless, it is necessary to be vigilant as animals can quickly get over-fat on all concentrate diets.

INTRODUCTION

There are three main categories of beef cattle to be fed in winter:

Weanlings – animals entering their first winter and which are at least a year from slaughter.

Stores – animals entering their second (or subsequent) winter which will be slaughtered during the following year.

Finishers – animals being finished over the winter.

From a feeding viewpoint, the main difference between weanlings and stores on the one hand, and finishers on the other, is that the former have time to exhibit compensatory growth. The main difference between weanlings and stores is that the former are still immature and relatively underdeveloped in terms of bone and muscle growth whereas the latter are more advanced in terms of bone and muscle growth.

Any discussion of winter feeding levels must be in the context of an overall production system. This is particularly so nowadays with premia/direct payments/agri-environmental payments contributing so much of the profit margin. All economic analyses of production systems demonstrate that profitability is maximised when the draw-down of direct payments is maximised. Thus, production systems must be designed to maximise the draw-down of direct payments, and feeding levels must then be designed to deliver these production systems. For example, there is no advantage in feeding high levels of concentrates to steers in their second winter if it results in the animals being finished and slaughtered before they are eligible for their second special beef premium.

FEEDING WEANLINGS

For most production systems the target weight gain for weanlings in winter is 0.5 to 0.6 kg/day. While these limits can be stretched on the basis of how well or poorly grown the animals are, in practice it is not possible to deviate too much from them.

Protein

One of the first questions usually asked is if weanlings require supplementary protein. While there are indeed many experiments showing protein responses by weanlings, the circumstances in which these occur are often unusual, i.e. the weanlings are light or poorly grown, the silage quality or preservation are poor or the responses are to feeds which are somewhat unique and generally expensive (i.e. fishmeal, sopralin).

A more general situation is outlined in Table 1 where well grown weanlings offered silage *ad libitum* received supplements of barley or barley/soyabean meal. There was no response to the inclusion of the soya. These results are typical of many others obtained in similar situations so it is concluded that in normal situations there is no need for a concentrate protein level higher than that found in barley. Furthermore, in many situations even where a protein response is obtained, it does not persist due to compensatory growth the following grazing season by the animals which did not receive the supplementary protein.

Table 1. Performance of weanlings fed silage plus barley or barley/soya.

Liveweight (kg)	Date	Day	Barley[1]	Barley/Soya[1]
Initial	Nov. 12	0	217	220
End Winter	Mar. 19	123	314	317
Mid Summer	July 7	237	429	425
End grazing	Oct. 23	345	501	498
Daily gain (g)				
Winter			762	763
Early summer			1042	981
Late summer			666	677
All summer			856	830
Overall			821	805

[1] 2kg/day, 140g/kg soya for barley/soya.

Environment

Pressure to reduce costs may result in more weanlings being fed outdoors (on land or pads) in winter. It is necessary to know if animals fed outdoors require more feed than those fed indoors. A comparison of weanlings fed silage only or silage plus barley either in a slatted shed (indoors) or on a sacrifice paddock (outdoors) in winter is shown in Table 2. Again the animals were well grown weighing about 220kg at the start of the winter.

Performance indoors and outdoors was generally similar both on silage only and silage plus barley. In fact daily gains were about 100g/day higher outdoors which could be attributed to a contribution from pasture at the start and towards the end of the experimental period. It is concluded that keeping weanlings outdoors in winter does not impair performance once feeding level and general management are comparable to those indoors.

Table 2. Performance of weanlings fed outdoors or indoors in winter.

			Outdoors		Indoors	
Barley (kg/day)			None	2kg	None	2kg
Liveweight (kg)	Date	Day	-	-	-	-
Initial	Nov 12	0	219	213	219	217
End winter	Mar 19	123	285	322	271	314
Mid summer	Jul 7	237	405	421	404	429
End grazing	Oct 23	345	493	495	483	501
Daily gain (g)						
Winter			523	858	409	762
Early summer			1090	900	1208	1042
Late summer			815	685	727	666
All summer			954	794	970	856
Overall			795	817	764	821

The response to concentrates was similar both outdoors (330g/day) and indoors (353g/day). This resulted in a mean weight difference at turnout of 40kg (318 v 278kg) in favour of those fed concentrates. During the early part of the grazing season, the animals fed silage only in winter gained 178g/day more (1149 v 971g). This fell to 95g/day (771 v 676g) in the later part of the season giving a mean difference of 137g/day (962 v 825g) for the grazing season as a whole. Thus, by the end of the grazing season the liveweight response of 40kg to concentrate feeding in winter was reduced to 10kg (498 v 488kg). This is a good example of the ability of animals to compensate for a period of inadequate feeding. Clearly, the extent of compensation will depend on the length of time when feeding was inadequate and the length of the subsequent period of adequate feeding.

Yeast

Numerous feed supplements have been produced over the years to improve the response to concentrates in cattle. One such is a yeast product – Diamond V. Yeast. This is sometimes included in commercial rations for both weanlings and finishing cattle. The effect of this product in weanlings fed 1.0kg concentrates per head daily is shown in Table 3. For the first 12 weeks of the winter period there was a significant response to yeast which thereafter declined to the end of the winter. However, by the end of the winter there was still an 8.0kg liveweight response to the yeast. Due to compensatory growth by the non yeast group over the subsequent grazing season this had declined to 2.0kg (i.e. the response had disappeared) by the end of the grazing season.

Table 3. Performance of weanlings offered Diamond V. Yeast.

Liveweight(kg)	Day	Control	Yeast
Initial	0	231	231
End winter	126	295	303
End grazing	294	459	461
Daily gain (g)			
Winter	126	513	570
Pasture	168	973	938
Overall	294	777	783
Silage intake (kgDM/day)		4.45	4.47

DM = Dry matter

Concentrate level

The main question in relation to weanling supplementation is what level of concentrates should be fed. Results relevant to this are shown in Table 4 where well grown weanlings (258kg initial liveweight) were fed either silage alone or with 1.5kg or 3.0kg concentrates per day.

There was a good response to concentrates in winter, 279g to the first 1.5kg and 255g to the second 1.5kg. At the end of winter the liveweight responses were 45 and 88kg to the 1.5kg/day and 3.0kg/day feeding levels, respectively. By the end of the grazing season these had fallen to 27kg and 43kg, respectively. The animals were then rapidly finished over 6 weeks on a high concentrate diet and slaughtered young at a light weight. At slaughter, the liveweight responses were 18kg and 21kg to the 1.5 and 3.0kg/day concentrate levels, respectively. Of interest here is that the comparison was continued through to slaughter rather than ending at the end of the grazing season and compensation continued through to slaughter.

Table 4. Performance of weanlings offered different concentrate levels.

		Silage only	Concentrates (kg/day) 1.5	3.0
Silage intake (kgDM/day)		4.12	3.81	3.45
<u>Liveweight (kg)</u>	<u>Day</u>			
Initial	0	258	258	259
End winter	163	303	348	391
End grazing	349	514	541	557
Slaughter	391	575	593	596
<u>Daily gain (g)</u>	<u>Days</u>			
Winter	163	275	554	809
Pasture	186	1134	1040	894
Finishing	42	1452	1224	924
Overall	391	810	856	861

[1]Barley based with 70g/kg soya.

Carcass data are shown in Table 5. The 18kg liveweight response to 1.5kg/day concentrates yielded 12kg carcass, and there was no difference in carcass weight between the 1.5kg and 3.0kg/day levels. There was no effect of concentrate level on conformation and the slightly greater fatness of the concentrate fed groups could be explained by their greater carcass weight. In economic terms the second 1.5kg/day concentrate increment was clearly uneconomic and even for the first 1.5kg/day increment, the cost of concentrates was greater than the value of the extra carcass production. This suggests that the optimum economic concentrate level is less than 1.5kg/day.

Table 5. Slaughter data for steers offered different concentrate levels as weanlings.

	Silage only	Concentrates (kg/day) 1.5	3.0
Carcass weight (kg)	311	323	323
Kill-out (g/kg)	540	546	543
Conformation[1]	2.48	2.54	2.38
Fat score[2]	3.39	3.48	3.43
Kidney & channel fat(kg)	13.2	14.4	14.1

[1]EU Beef Carcass Classification Scheme, scale P=1 to E=5
[2]EU Beef Carcass Classification Scheme, scale 1=leanest to 5=fattest

Liveweight

Responses to concentrates are generally greater in lighter animals (a fixed level of concentrates constitutes a higher proportion of the total feed intake and nutrient requirements) and there is little compensatory growth in calves following differential feeding. Accordingly, it could be hypothesised that responses, both in winter and subsequently, would be greater in light weanlings. There is certainly reliable data showing that little or no compensatory growth occurs in animals below about 150 kg, but above this weight, the data are equivocal.

Over 20 years ago, work at Grange examined the response to supplementary concentrates in light (160kg) and heavy (200kg) weanlings (Table 6). Performance on silage only was low at around 0.25kg/day so there was a large response to concentrates which was similar for the two types of animals. At pasture, there was compensatory growth by the animals not fed concentrates in winter but the light animals fed concentrates retained more of their extra weight gain than did the heavy animals. This trend continued into finishing.

Table 6. Effect of initial liveweight on performance of weanlings fed differently.

Initial weight		Light		Heavy	
Winter feeding		Silage	Silage +	Silage	Silage +
Liveweight (kg)	Day	only	conc	only	conc
Initial	0	165	163	204	203
End winter	149	201	279	244	319
End grazing	356	355	407	401	427
Slaughter	481	442	491	492	513
Carcass weight (kg)		244	274	274	290
Daily gain (g)	Days				
Winter	149	242	`779	269	779
Pasture	207	744	618	759	522
Finishing	125	696	672	728	688
Overall	481	576	682	599	645

Source: Drennan and Harte, (1979), Irish Journal of Agricultural Research 18: 145-156

Feeding concentrates in winter increased slaughter and carcass weight in light weanlings by 49kg and 30kg, respectively. The corresponding values for heavy weanlings were 21kg and 16kg. Thus, it is concluded that while the immediate response to concentrates was similar for both light and heavy animals, the light animals retained more of that response (49 of 78kg) than did the heavy animals (21 of 75kg). Thus, higher levels of concentrates are warranted (and in any event are generally necessary to meet system targets) for light than for heavy weanlings.

Overall efficiency

Averaged across a large number of trials, the overall efficiency of conversion of concentrates to liveweight both at the end of the winter and at the end of the following grazing season together with the effects on silage intake in winter are shown in Table 7. For example, when the concentrate level in winter is 1.0kg/day the conversion rate to liveweight at the end of the winter is about 4.5:1. Approximately 65% of this extra liveweight is retained to the end of the following grazing season giving a conversion rate at that time of about 7:1.

Table 7. Concentrate supplementation – weanlings.

Concentrates (kg/day)	Conversion (winter)	Retained at Pasture (%)	Conversion (end grazing)	Silage dry matter reduction (kg)[1]
1	4.5	65	7.0	1.8
2	5.5	55	10.0	3.0
3	7.0	45	15.5	5.3

[1] **Per kg extra liveweight gain at the end of the grazing season based on reductions in silage DM intake of 0.3, 0.7 and 1.1 kg/day for concentrate supplementation levels of 1,2 and 3 kg/day, respectively.**

For every 1.0kg extra liveweight at the end of the grazing season, winter silage dry matter (DM) intake is reduced by about 1.8kg. As the level of concentrate feeding increases, efficiency declines, the proportion of the extra gain retained declines and there is a greater reduction in silage intake. From these data it is possible to make an economic assessment of weanling supplementation in winter.

Economics

Based on the data in Table 7, the costs of the extra liveweight at the end of the grazing season from various levels of winter supplementation and concentrate prices are shown in Table 8. Valuing liveweight at £1.00/kg, it is clear that it is profitable to feed 1.0kg/day up to a concentrate price of £160/t. Only when concentrates are less than £120/t is 2.0kg/day justified and more than 2.0kg/day is never justified.

Table 8. Costs (p/kg liveweight)[1] of winter concentrate supplementation of weanlings.

	Concentrate (£/t)			
Concentrate level (kg/day)	100	120	140	160
1	58	72	86	100
2	79	99	119	139
3	118	149	180	211

[1]Extra at the end of the following grazing season assuming a silage value of 7 p/kg DM.

FEEDING STORES

Store steers which are approaching 500kg in autumn can be finished over the following winter and slaughtered in spring or held over for finishing off pasture the following grazing season. The response of such animals to concentrate supplementation in winter and their performance the following grazing season if not slaughtered beforehand are shown in Table 9. Charolais x Steers about 19 months of age and 500kg liveweight were fed either 0, 3.0 or 6.0kg/day concentrates over a long (172 days) winter period and either slaughtered then or put to pasture for a grazing season of similar duration. The silage was of moderate quality and supported a liveweight gain when fed alone of 0.3kg/day.

Table 9. Responses and subsequent performance of steers fed different concentrate levels.

Concentrates (kg/day)		0	3	6
Liveweight (kg/day)	Day	-	-	-
Initial	0	501	501	500
End winter	172	554	615	654
Eng grazing	344	710	731	737
Liveweight gain (g/day)	Days			
Winter	172	311	664	893
Pasture	172	908	675	470
Carcass gain (g/day)				
Winter	172	227	447	605
Pasture	172	510	407	268

The response to the first 3.0kg/day concentrate increment was 353g/day and that to the second 3.0kg/day increment was 229g/day. End of winter liveweight responses were 61kg and 100kg for the 3.0kg and 6.0kg/day levels, respectively. When animals fed these concentrate levels in winter were put to pasture for the following grazing season, corresponding liveweight gains at pasture were 908, 675 and 470g/day and the liveweight responses at the end of the grazing season were 21kg and 27kg for the 3.0kg and 6.0kg/day concentrate levels, respectively.

Slaughter data for the animals are shown in Table 10. When slaughtered in spring (i.e. at the end of the 172 day winter feeding period), the carcass weight responses to 3.0kg and 6.0kg/day concentrates were 38kg and 65kg, respectively. Conformation improved with increasing level of concentrates and fat score increased. However, fat score was quite acceptable for all groups. Leaving slaughter until the end of the grazing season increased carcass weight by 87kg for animals fed no concentrates in winter. There were parallel improvements in conformation and increases in fatness. The carcass responses to concentrates were 21kg and 25kg for the 3.0kg and 6.0kg/day levels, respectively. Conformation was slightly better for the animals fed concentrates. All of the extra liveweight due to concentrate feeding was recovered as carcass in animals slaughtered at the end of the grazing season.

Table 10. Slaughter data of steers fed different concentrate levels.

	Spring			Autumn		
Concentrates (kg/day)	**0**	**3**	**6**	**0**	**3**	**6**
Carcass weight (kg)	298	336	363	385	406	410
Kill-out (g/kg)	538	546	555	542	555	556
Kidney & channel fat(g/kg)	32	45	44	38	36	43
Conformation	2.7	3.0	3.5	3.2	3.6	3.6
Fat score	3.0	3.5	3.8	3.7	3.8	3.9

The linear regressions of liveweight and carcass weight gains on concentrate level in winter and of liveweight gains at pasture on liveweight gain in winter are shown in Table 11. The data show that per kg concentrates fed in winter, daily liveweight gain in winter increased by 96g but liveweight gain at pasture decreased by 73g.

Corresponding values for carcass gains were 63g and 40g. For every 1.0kg extra gain per day in winter, liveweight gain at pasture decreased by 880g/day in the early part of the grazing season (first 93 days), 345g/day in the later part of the season (93 to 172 days) and 634g/day for season as a whole.

Table 11. Regressions on winter concentrate level and winter gain.

Concentrate = X	a	b
Liveweight gain – winter	328	96
Liveweight gain – pasture	903	-73
Carcass gain –winter	237	63
Carcass gain – pasture	516	-40
Winter gain = X		
Liveweight gain 172 to 265d	1119	-880
Liveweight gain 265 to 344d	1043	-345
Liveweight gain 172 to 344d	1084	-634

Leaving aside the responses to concentrates by animals slaughtered in spring (it will be dealt with later), for animals destined for finishing off pasture, supplementary concentrates in winter of greater than 3.0kg/day cannot be justified in that it had negligible effects on carcass weight and grades. Even the 3.0kg/day level cannot be economically justified in that it would require a response of about 35kg carcass weight to cover the cost while the actual response was only 21kg carcass weight. The small improvement in conformation would go some way towards closing the gap and it would be closed further if feeding was based on a normal winter period of about 140 days, rather than the 172 days used. Nevertheless, it must be concluded that the economic optimum level of concentrate supplementation in winter for store animals destined for finishing off pasture later is less than 3.0kg/day.

Table 12. Performance of steers fed silage or silage plus concentrates in winter.

Liveweight	Day	Silage only	Silage + 1.5kg conc
Initial	0	553	553
End winter	138	630	647
Slaughter	257	723	731
Carcass weight		391	392
Daily gain(g)			
Winter	138	559	685
Pasture	119	785	705
Overall	257	664	694

The response to a lower level (1.5kg/day) of supplementary concentrates was then examined in which stores of 553kg initial liveweight were fed silage only or silage plus 1.5kg/day concentrates over a 138 day winter period. The animals were slaughtered after a further 119 days at pasture. Performance on silage alone at 0.56kg/day was good, (Table 12). The response to concentrate supplementation in winter was 126g/day giving a liveweight increase of 17kg at the end of winter. By the end of the grazing season this had declined to 8kg and there was no difference in carcass weight. It is concluded that in these circumstances, feeding 1.5kg/day concentrates in winter was not economically justified. However, it should be noted that the cattle were quite heavy at the start (553kg) and performance on silage alone was quite good (559g/day) With lighter cattle and/or poorer quality silage a better response would be expected.

In conclusion, it can be stated that the optimum level of concentrate supplementation for store cattle in winter is in the range 0 to 1.0kg/day. For practical purposes, the general recommendation is none, but where silage is scarce or quality poor, feeding up to 1.0kg/day concentrates will cover its costs.

FINISHING CATTLE

Planning feeding regimens for finishing cattle must be in the context of production systems, dates of premia eligibility, and facilitating participation in schemes such as extensification and the Rural Environment Protection Scheme (REPS). A strict input/output cost/margin analysis might indicate a certain optimum level of concentrate feeding but an overall system analysis might show a higher optimum if for example it resulted in earlier slaughter of the animals but facilitated collection of the extensification premium at the higher rather than the lower rate.

Silage quality

Before considering the responses to concentrate supplementation, it is worthwhile first considering the effects of silage quality. As silage quality improves, *ad libitum* intake increases (Table 13). Consequently, less concentrates are required to achieve a fixed daily gain target. Thus, while silage costs increase (greater intake, higher cost of higher quality silage), concentrate costs decrease to a greater extent, so total feed costs decrease. In the example taken, feed costs decrease by 2p/kg liveweight gain for each 1% unit increase in silage dry matter digestibility (DMD). Silage intake increases by about 0.2kg/day per 1% unit increase in silage DMD and each 1% unit DMD is equal to 0.25 to 0.35kg concentrates.

Table 13. Silage digestibility (DMD) and feed costs[1]

Silage DMD (%)	65	70	75
Silage DMI (kg/day)	4.3	5.2	6.5
Concentrate (kg/day)	7.2	5.8	4.0
Silage costs[2] (£)	42	55	73
Concentrate costs[3] (£)	140	113	78
Total costs (£ per 150 days)	182	168	151
Cost of LWG (p/kg)	121	112	101

[1]For 1.0 kg/day LWG; [2]65, 70 and 75 £/t DM for DMD 65, 70 and 75%, respectively; [3]£130/t. DMD = Dry matter digestibility ; DMI = Dry matter intake; LWG=Liveweight gain

Heifers

Responses of Charolais x heifers to 0, 3.0 and 6.0kg/day concentrates with silage *ad libitum* are shown in Table 14. Silage intake was quite high and surprisingly, the reduction in intake was no greater for the second (1.44kg/day) than for the first (1.49kg/day) 3.0kg/day concentrate increment. Accordingly, the increase in ME intake was as great for the second concentrate increment as for the first (17MJ). (Usually, the reduction in silage intake is greater and so the increase in total ME intake is less for each successive concentrate increment. Daily gain on silage only was 515g/day overall.

Table 14. Response of Charolais x Friesian heifers to supplementary concentrates.

Concentrates (kg/day)	0	3	6
Silage intake (kgDM/d)	7.32	5.83	4.39
Total intake (kgDM/d)	7.32	8.35	9.43
Total ME intake (MJ/d)	73	90	107
Daily gains (g)			
0 to 80 days	587	931	1126
80 to 167 days	449	668	704
0 to 167 days	515	794	906

The response to the first 3.0kg/day concentrate increment was 279g/day but the response to the second 3.0kg/day increment was only 112g/day, notwithstanding the similar increase in ME intake. A point worth noting in the data is the big reduction in performance in the period after 80 days compared to the first 80 days. For the silage only, 3.0kg/day and 6.0kg/day concentrate treatments, growth rate was 138g/day, 263g/day and 422g/day lower in the period 80 to 167 days than in the period 0 to 80 days. Clearly, length of finishing period has a major influence on overall performance and for heifers particularly, the finishing period should be kept as short as possible consistent with producing an acceptable carcass.

Table 15. Slaughter data for Charolais x Friesian heifers fed supplementary concentrates.

Concentrates (kg/day)	0	3	6
Slaughter weight (kg)	496	543	561
Kill-out (g/kg)	528	537	541
Carcass weight (kg)	262	292	304
Kidney & channel fat (g/kg)[1]	42	46	47
Conformation	2.9	3.2	3.2
Fat score	3.2	3.5	3.7

[1]Of carcass; Initial liveweight = 410kg

Slaughter data are shown in Table 15. The 3.0kg and 6.0kg/day concentrate levels increased slaughter weights by 47 and 65kg, respectively. Corresponding carcass weight increases were 30 and 42kg. Kill-out increased by 11g/kg for the first 3.0kg/day concentrate increment but the additional increase for the second 3.0kg/day increment was only 4g/kg. Conformation improved and fatness increased due to feeding 3.0kg/day concentrates compared with silage only, but there was little further effect of feeding 6.0kg/day concentrates. Clearly, the feeding of 6.0kg/day for the entire period could not be economically justified but feeding it for the first 80 days might be justified because of the very good response during this time. Feeding the 3.0kg/day level was just about profitable for the full period but could readily be justified for a shorter period.

Data from a second experiment on responses to concentrates by mixed breed heifers are shown in Table 16. Feeding 3.0kg/day concentrates increased liveweight gain by 567g/day and carcass gain by 350g/day. Carcass weight was increased by 48kg. Conformation was improved by 0.7 class and fat score was increased by 1.1 class. Feeding a second 3.0kg/day increment further increased liveweight and carcass gain by 142g and 128g/day, respectively. This resulted in an extra 16kg carcass weight. There were only small effects on carcass grades. The results agree generally with the previous experiment on the response to 6.0kg/day compared to 3.0kg/day but the overall response to the 3.0kg/day level was greater than in the previous experiment. The main reasons for this were lighter animals and poorer performance on silage only.

Table 16. Response of mixed breed heifers to supplementary concentrates.

Concentrates (kg/day)	0	3	6
Daily gain (g)			
Liveweight	226	793	935
Carcass	104	454	582
Initial liveweight (kg)	395	396	396
Slaughter weight (kg)	425	502	520
Kill-out (g/kg)	507	523	537
Carcass weight (kg)	215	263	279
Kidney & channel fat (g/kg)[1]	28.4	39.5	41.2
Conformation	2.0	2.7	3.0
Fat score	2.6	3.7	3.9

[1]Of carcass.

Overall efficiency

Averaged over a number of experiments such as those described, the efficiency of use of each additional 1.0kg concentrate increment for carcass production and the corresponding quantities of silage substituted were calculated (Table 17). With increasing concentrate level efficiency of utilization declines (i.e. the 3rd kg/day concentrate increment is converted to carcass at a ratio of 12:1 whereas for the 5th increment the ratio is 18:1) but the substitution rate of silage increases (i.e. for every 1.0kg extra carcass obtained from the 3rd kg concentrate increment, silage intake is reduced by 6.0kg DM whereas for the 5th kg increment, silage intake is reduced by 11.0kg DM).

Table 17. Carcass efficiency and silage substituted per kg concentrates for heifers

Concentrate increment (kg)	Carcass efficiency[1]	Silage substituted[2]
3rd	12.0	6.0
4th	14.5	8.0
5th	18.0	11.0
6th	22.0	14.0
7th	27.0	18.0
8th	33.0	22.0

[1]kg concentrates per kg carcass; [2]kg DM per kg carcass gain.

Economics

From these data the cost of each additional 1.0kg carcass gain for each 1.0kg concentrate increment can be calculated (Table 18). Obviously, as concentrate costs increase, less concentrates can be economically justified (ignoring other factors such as system requirements and direct payments). In general up to 4.0kg/day concentrates can be fed while concentrates costs do not exceed £160/t. At £140/t up to 5.0kg/day can be fed while 6.0kg/day can be fed if concentrates are only £120/t. Below £100/t, concentrates can be fed *ad libitum*.

Table 18. Cost of carcass gain (p/kg) for heifers

	Concentrates (£/t)			
Concentrate increment (kg)	**100**	**120**	**140**	**160**
3rd	78	102	126	150
4th	89	118	147	176
5th	103	139	175	211
6th	122	166	210	254
7th	144	198	252	306
8th	176	242	308	374

Steers

There have been many experiments to examine the response in finishing steers to concentrate supplementation. The results of one are shown in Table 19 in which steers of around 520 kg initial liveweight were fed 0, 3.0kg or 6.0kg/day concentrates with silage *ad libitum*. Liveweight gain on silage alone was very good at 658g/day. The liveweight responses to the first and second 3.0kg/day increments were 311g and 117g/day, respectively. Corresponding carcass gains were 221g and 74g/day.

Table 19. Response of Charolais x Friesian steers to supplementary concentrates

Concentrates (kg/day)	0	3	6
Initial liveweight (kg)	523	523	523
Final liveweight (kg)	618	663	680
Kill-out (g/kg)	518	531	533
Carcass weight (kg)	320	352	363
Kidney & channel fat (g/kg)[1]	38.4	44.3	51.2
Conformation	2.3	2.8	3.0
Fat score	2.6	3.9	4.0
Daily gain (g)			
Liveweight	658	969	1086
Carcass	411	632	706

[1]Of carcass

It is worth noting that 65-70% of the liveweight gain was recovered as carcass. Kill-out increased greatly with the first concentrate increment but not thereafter. Conformation improved with increasing concentrate level (and carcass weight) and fatness increased. There was rather poor agreement between fatness as indicated by kidney plus channel fat proportion (objective measurement) and fat score (subjective measurement). Overall performance was good because performance on silage alone was good.

Efficiency

Averaged across a number of experiments (such as that summarised in Table 19), the efficiency of conversion of concentrates to carcass and the substitution of silage by concentrates are shown. For the 3rd 1.0kg concentrate increment, the conversion rate to carcass is about 14:1 whereas for the 6th 1.0kg increment, the conversion rate is about 20:1 (Table 20). Similarly, for every kg of carcass derived from feeding the 3rd kg concentrate increment there is a saving of about 7.0kg silage DM. This increases to 13kg of silage DM saved per kg carcass produced from the 6th kg concentrate increment.

Table 20. Carcass efficiency and silage substituted per kg concentrates in steers

Concentrate increment (kg)	Carcass efficiency[1]	Silage substituted[2]
3rd	14.0	7.0
4th	15.5	8.5
5th	17.5	10.5
6th	20.0	13.0
7th	23.0	16.0
8th	27.5	20.0

[1]kg concentrates per kg carcass; [2] kg DM per kg carcass gain

Economics

The cost per kg carcass gain for each additional 1.0kg concentrate increment (above the 2nd) at various concentrate prices is shown in Table 21. If carcass is valued at around £2.00/kg then when concentrates cost £160/t, no more than 4.0kg/day can be justified economically. As concentrate price falls the level of supplementation can increase. At £140/t, 6.0kg/day can be fed, at £120/t, 8.0kg can be fed and below £100/t, concentrates can be fed *ad libitum*. In brief, the economic optimum level of concentrate supplementation for finishing steers varies by about 1.0kg/day per £10/t change in concentrate price.

Table 21. Cost of carcass gain (p/kg) for steers

Concentrate	Concentrates (£/t)			
increment (kg)	100	120	140	160
3rd	91	119	147	175
4th	96	127	158	189
5th	102	137	172	207
6th	109	149	189	229
7th	118	164	210	256
8th	135	191	245	300

Silage substituted valued at 7 p/kg DM

Durat ion of Finishing

Reference has been made on a number of occasions previously to the changing responses and performance levels over the finishing period. This is demonstrated more clearly in Table 22 which shows the performance in two treatments of an experiment (silage only and silage + 6.0kg/day concentrates) for the first 56 days, the following 42 days and the final 49 days of a 147 day finishing period.

Over the first 56 days steers fed silage only gained 804g/day while those fed 6.0kg/day supplementary concentrates gained 1430g/day. Over the next 42 days these values dropped to 591g/day and 1024g/day for the silage only and the silage plus concentrate treatments, respectively. There were further drops to 539g/day and 789g/day over the final 49 days. Thus, while the mean values of 655 and 1101g/day for silage only and silage plus concentrates were very good, they comprised quite high values in the early part, and much lower values in the latter part, of the finishing period.

Table 22. Daily gains (g) and segment of finishing period

Finishing interval (d)	Silage only	Silage + 6 kg concentrate
0-56	804	1430
56-98	591	1024
98-147	539	789
0-147	655	1101

Pattern of Concentrate Supplementation

Traditionally, experiments to measure the response to concentrate supplementation used flat rate feeding (i.e. a flat rate of for example 3.0kg or 6.0kg/day over the experimental period). Farmers generally used this approach also although some would have raised the level of supplementation in the weeks immediately before slaughter. With the arrival of direct payments accompanied by retention times and related issues, farmers could no longer sell cattle immediately they were ready so in some cases at least, finishing had to be planned to specific calendar dates. In this situation flat rate feeding was not appropriate. Accordingly, a number of experiments were carried out where flat rate feeding was compared with modulated feeding. The results of one such study are shown in Table 23.

Table 23. Performance of steers fed different concentrate patterns

Feeding pattern	FLAT	STEP	AD LIB
Silage intake (kgDM/day)	4.91	4.94	4.32
Conc. Intake (kgDM/day)	3.96	4.19	5.12
Daily gain (g)			
0-42 days	1145	714	226
42-84 days	912	1119	1002
84-126 days	848	1264	1876
0-126 days	968	1033	1035

Over a 126 day finishing period, animals were fed either a flat rate of 5kg/day concentrates, or they were fed the same target total concentrate allowance stepped (i.e. 2.5, 5.0 and 7.5kg/day for the 1st, 2nd and 3rd one-thirds of the finishing period) or *ad libitum* over the final half of the finishing period. There was no difference between the flat and stepped treatments in silage or concentrate intakes, but the *ad libitum* group consumed less silage and more than the target level of concentrates (it is not desirable to restrict concentrates when animals are being fed *ad libitum*).

As would be expected, there were big differences between the treatments in the pattern of performance over the finishing period. As shown already, the group fed the flat level had high gains initially which declined with time. Conversely, the stepped group had lower gains initially which increased as the level of concentrates increased, while the *ad libitum* group had very low gains initially when fed silage only and very high gains at the end when fed concentrates *ad libitum* . Overall, for the entire finishing period liveweight gain was similar for all treatments.

Table 24. Slaughter and carcass traits of steers fed different concentrate patterns

	FLAT	STEP	AD LIB
Initial liveweight (kg)	523	523	523
Slaughter weight (kg)	645	653	653
Kill-out (g/kg)	521	512	521
Carcass weight (kg)	336	334	340
Kidney & channel fat (g/kg)[1]	47	44	41
Conformation	2.68	2.41	2.77
Fat score	3.76	3.67	3.51
ME/kg carcass gain (MJ)	161	169	166

[1]Of carcass

Slaughter and carcass data are shown in Table 24. There was no difference between the treatments in kill-out, carcass weight, conformation or efficiency of conversion of ME to carcass. However, both kidney plus channel fat proportion and fat score decreased as feeding pattern changed from flat to *ad libitum*. It was concluded that pattern of concentrate supplementation did not affect performance or efficiency but did affect carcass fatness. This aspect was further examined for the extreme treatments using both Friesian and Charolais x Friesian steers (Table 25).

Table 25. Performance of Charolais x Friesian (CH) and Friesian (FR) steers fed different concentrate patterns

	FLAT		AD LIB	
	CH	FR	CH	FR
Silage intake (kg DM)	655	754	631	646
Conc.intake (kgDM)	609	622	712	662
Total intake (kgDM)	1264	1376	1343	1308
Daily gain (g)				
0-53 days	1313	1122	676	599
53-98 days	915	902	987	956
98-137 days	805	1077	1815	1849
0-137 days	1041	1039	1104	1073

At the flat rate of feeding, the Friesians consumed 15% more silage (concentrate level was fixed) and 9% more total DM than the Charolais crosses. For the *ad libitum* treatments, silage intake was again slightly higher for the Friesians but concentrate intake and total DM intake tended to be higher for the Charolais crosses. This indicates that Friesians had a higher intake of silage only or silage plus concentrates fed at a flat level, but when concentrates were fed *ad libitum* Charolais crosses had at least as high an intake as Friesians.

Performance followed the usual trends of a decline with time for the flat treatment and an increase with time for the *ad libitum* treatment. There was no difference in performance between the Friesians and Charolais crosses, and the slightly higher performance of the Charolais crosses on the *ad libitum* treatment could be attributed to their higher intake. Overall, it was concluded that at the same levels of intake there was no difference between flat rate and *ad libitum* feeding.

Table 26. Slaughter and carcass traits of Charolais x Friesian (CH) and Friesian (FR) steers.

	FLAT		AD LIB	
	CH	FR	CH	FR
Initial liveweight (kg)	522	519	522	519
Slaughter weight (kg)	665	662	674	666
Kill-out (g/kg)	532	513	536	513
Carcass weight (kg)	354	339	361	342
Kidney & channel fat (g/kg)	46.8	53.4	37.7	47.7
Conformation	3.09	2.08	3.23	2.17
Fat score	4.00	3.94	3.68	3.58
ME/kg carcass gain (MJ)	158	176	157	164

Carcass traits are shown in Table 26. There was no difference in slaughter weight between Friesians and Charolais crosses but as the Charolais crosses had about 20g/kg higher kill-out, carcass weight was 17kg greater. Charolais crosses had about one class better carcass conformation than Friesians but had similar carcass fat scores and a better rate of conversion of ME to carcass.

There was no difference in kill-out between the two feeding treatments (although a higher value could be expected for the *ad libitum* treatment), but the *ad libitum* treatment tended to have slightly better carcass conformation and efficiency of conversion of ME to carcass. The main difference between the feeding treatments was in carcass fatness. In terms of kidney plus channel fat proportion, the flat rate treatment animals were 17% fatter than those on the *ad libitum* treatment while in terms of fat score the difference was 9% or one third of a fat class. Thus, probably because of the restriction of silage over the final half of the finishing period, the *ad libitum* approach reduced carcass fatness.

Other possible advantages of the *ad libitum* approach include simplification of management (silage only initially and predominantly concentrates thereafter), reduced machinery requirements, increased whiteness of the fat colour and meeting the specifications of producer group schemes which require animals to be fed on high concentrate levels for 10-12 weeks before slaughter. This can be achieved without any increase in overall concentrate input.

FINISHING CATTLE ON HIGH CONCENTRATE DIETS

For a country with the capacity to produce more grass than can be utilised by its ruminant population, which cultivates the image of extensive grass-based beef production, and where production costs must be lower than those of our competitors, it is difficult to justify large scale production of beef on high concentrate diets. However, there are a number of producer/processor schemes which pay premia for concentrate finished cattle and with silage costs continually increasing, there are some opportunities and requirements for high concentrate feeding. The three most common high concentrate feeding systems are (i) barley beef production (ii) finishing weanling bulls from the suckler or dairy herds and (iii) rapid finishing of stores, predominantly steers but occasionally heifers.

Barley Beef Production

This system evolved in Britain in the 60's and early 70's, when dairy calves and concentrates were cheap but carcass price was relatively high because of the deficiency payment system. Although it is associated with barley being the main feed ingredient, it can be based on any high energy feed including by-products and root crops. It involves the rearing of animals from calfhood to slaughter on *ad libitum* concentrate diets.

For the system to be profitable concentrates must be cheap and calves must also be relatively cheap and of high growth potential. Thus Friesian/Holstein calves (which are cheap) reared as bulls (for high growth rate) are commonly used. Slaughter age ranges from 10 to 13 months and carcass weight ranges from 200 to 270kg. As feed cost per kg carcass weight increases, and the overhead cost of the calf per kg carcass weight decreases, with increasing slaughter weight, the optimum slaughter weight is a balance between the increasing feed cost and decreasing calf cost per kg carcass weight. Thus, when calves are expensive and concentrates are cheap the optimum slaughter weight is high, whereas when calves are cheap and concentrates are expensive the optimum slaughter weight is lower. In Ireland, both calves and concentrates are always relatively expensive, so profit margins from the system are low or may be negative.

Table 27. Performance of Friesian bulls in a barley beef system.

	Start to 168 days	168 to 280 days	Start to 280 days
Liveweight gain (kg/day)	1.32	1.14	1.25
Concentrate intake (kg/day)	6.9	8.2	7.4
Slaughter weight (kg)			448
Carcass weight (kg)			250
Efficiency			
Liveweight	5.2	7.2	5.9
Carcass			10.3

[1]kg concentrates per kg gain

The results from a cereal beef production experiment at Grange some years ago are shown in Table 27. Friesian bull calves were conventionally reared to about 3 months of age and 99kg liveweight. They were then placed on *ad libitum* concentrates (plus a small quantity of roughage to maintain rumen function) until slaughter about 9 months later. Average daily gain was higher in the first 6 months (1.32kg/day) than during the final 3 months (1.14kg) with an overall average of 1.25kg/day. Feed intakes for the first 6, final 3, and total 9 month periods were 6.9, 8.2 and 7.4kg/day giving corresponding feed to liveweight gain ratios of 5.2, 7.2 and 5.9. These data demonstrate how intake increases while performance and efficiency decrease with increasing weight. Mean slaughter and carcass weights were 448kg and 250kg, respectively. Estimated carcass gain was 0.72kg/day and feed to carcass ratio was 10.3.

In summary, a 250kg carcass was produced from a 3-month-old reared calf with just over 2.0 t concentrates. Thus, at concentrate and calf prices of £130/t and £140, respectively and a carcass price of £2.00/kg, there is a margin of about £100 per animal available to cover all other costs (including calf rearing and interest) and leave a profit. This system will have little application in Ireland for so long as the possibility of calf exports keep calf prices high and concentrates remain expensive.

Young Bulls

The most likely type of young bulls to be finished on high concentrate diets are continentals from the suckler herd. Another type of animal commonly available is early born Holstein/Friesians which have spent their first summer at grass and are fairly well grown. Such Holstein/Friesians animals were fed on *ad libitum* concentrates for 6 months (179 days) or 9 months (272 days). Daily gain over the first 6 months was about 1.4kg/day. This fell to 1.2kg/day for the period 6 to 9 months (Table 28). Slaughter weight was 550kg after 6 months or 670kg after 9 months. Kill-out was high giving carcass weights of 300kg and 377kg for the 6 and 9 months slaughter groups, respectively. Conformation was about 50:50 R:O after 6 months and predominantly R after 9 months. Fat score averaged slightly over 3.

Table 28. Performance and slaughter traits of Holstein/Friesian bulls finished on concentrates for two periods.

Finishing period (days)	179	272
Period gain (g/d)[1]	1395	1200
Overall gain (g/d)[2]	1395	1328
Slaughter weight (kg)	550	670
Kill-out (g/kg)	554	563
Carcass weight (kg)	300	377
Conformation	2.6	3.1
Fat score	3.1	3.2

[1] 0 to 179 days for 179 day slaughter group, 179 to 272 days for 272 day slaughter group . [2] 0 days to slaughter for both groups.

Feed requirements and efficiency are shown in Table 29. Concentrate consumption was about 1.76t for 6 months and 3.0t for 9 months. Efficiency of conversion of ME to liveweight averaged about 90MJ/kg and declined with increasing length of finishing. Valuing concentrates and silage at £140/t and £15/t, respectively gives total feed costs of about £260 for 6 months. Valuing the weanling at £250 brings the total costs of animal plus feed to £550. At a carcass weight of 300kg and a value of £2.00/kg this leaves a margin of £50 plus the bull premium, the slaughter premium and any other direct payments for which the animal is eligible.

Table 29. Feed intakes and efficiency of Holstein/Friesian bulls finished at two weights.

Finishing period (days)	179	272	200[1]
Concentrates (kg)	1763	2988	1860
Silage (t)	0.90	1.36	1.00
Liveweight gain (kg)	246	365	300
Efficiency (MJ/kg)	85	96	101

[1]For Charolais x Friesians, not comparable with the others, calculated for Charolais x Friesian bulls taken from 300kg initial liveweight to 340kg carcass weight.

The data in the third column of Table 29 are not from this experiment but are calculated from another experiment in which Charolais x young bulls were finished to slaughter on a high concentrate diet. The data shown are those relevant to taking a 300kg weanling to a slaughter weight of 600kg and a carcass weight of 340kg. Feed costs and margins would be similar to those for the Holstein/Friesians.

Finishing Heifers

There is little information available on the finishing of store heifers on high concentrate diets. Generally, it is considered that heifers do not have the potential to benefit from such high energy feeding and can readily be finished on cheaper feeds. This is generally so but heifers of high growth potential (e.g. continentals and animals with potential for compensatory growth) can be economically finished on all concentrate diets.

Feed intake, performance and slaughter data for continental cross heifers finished on all concentrates are outlined in Table 30. The heifers consumed about 10kg concentrates per day in addition to a small quantity of silage. Daily liveweight gain was 1.27kg and daily carcass gain was 0.79kg. Conformation was a mix of R and U while fat score was a mix of 4L and 4H. This indicates that the carcasses were somewhat overfat and that the heifers should have been slaughtered at a carcass weight lower than 307kg, i.e. at around 280kg. The time and feed required to take the animals to 280kg carcass weight are shown in Table 31. It is assumed that starting weight is 395kg and that daily gain remains the same (i.e. 1.27kg/day).

Table 30. Feed intake and performance of continental cross heifers[1]

Silage intake (kgDM/day)	1.1
Concentrate intake (kgDM/day)	8.4
Liveweight gain (g/day)	1274
Carcass gain (g/day)	788
Slaughter weight (kg)	566
Kill-out (g/kg)	542
Carcass weight (kg)	307
Conformation	3.4
Fat score	4.0

[1]Initial liveweight 395kg, 133 day feeding period.

Table 31. Feed required to produce a 280kg[1] carcass.

Days to slaughter	99
Silage (t)	0.8
Concentrates (kg)	960
Efficiency (MJ/kg liveweight)	95

[1]520kg slaughter liveweight, initial weight 395kg

Finishing Steers

The most comprehensive evaluation of high concentrate finishing of steers was where Charolais x Friesians of approximately 500kg initial liveweight were fed on concentrates *ad libitum* for 12 or 23 weeks before slaughter. Gains and intakes are shown in Table 32. For the first 12 weeks, liveweight gain was 1.42kg/day and carcass gain was estimated at over 1.0kg/day. Concentrate intake was about 12kg/day giving a feed conversion to liveweight ratio of about 8.5:1 and a feed conversion to carcass ratio of about 11.5:1. Compared with the first 12 weeks, over the next 11 weeks, liveweight gain declined by 266g/day, carcass gain declined by 196 g/day, and concentrate intake increased by over 1.0kg/day. Accordingly, efficiency of conversion of feed to liveweight and carcass declined by almost 40%. These data clearly indicate that where high concentrate feeding is practised the feeding period should be as short as possible consistent with producing an acceptable carcass.

Table 32. Performance of Charolais x steers fed a high concentrate diet from start to 12 weeks and from 12 to 23 weeks.

Finishing period	Start to 12 weeks	12 to 23 weeks
Liveweight gain (g/day)	1424	1158
Carcass gain (g/day)	1036	840
Concentrates intake (kg/d DM)	10.2	11.4
Concentrate DM to gain:[1]		
Liveweight (kg/kg)	7.16	9.85
Carcass (kg/kg)	9.85	13.57

[1]Silage not included.

Slaughter data for these two groups together with values for a group slaughtered pre-experimentally are shown in Table 33. Over the first 12 weeks, kill-out increased by almost 40g/kg, fatness increased considerably and conformation improved by almost 1.5 classes. These changes corresponded to a carcass gain of 85kg. From 12 to 23 weeks there was a carcass gain of 67kg (i.e. almost 80% of that for the earlier period). However, this was accompanied by only 11g/kg increase in kill-out. Fatness as indicated by kidney plus channel fat increased more rapidly than previously although this was reflected in only a small increase in fat score. The extra improvement in conformation was also small. In brief, in terms of carcass traits most of the improvement had been obtained by 12 weeks with little further improvement (and deterioration in fatness) thereafter.

Table 33. Slaughter data for Charolais x steers fed a high concentrate diet and slaughtered after 12 or 23 weeks.

Finishing period (weeks)	0[1]	12	23
Slaughter weight (kg)	507	625	732
Carcass weight (kg)	256	341	408
Kill-out (g/kg)	508	547	558
Kidney plus channel fat (kg)	5.8	12.0	20.0
Kidney plus channel fat (g/kg)[2]	23	35	49
Fat score	2.22	3.69	3.90
Conformation	2.00	3.44	3.78

[1]Pre-experimental slaughter group [2] Of carcass weight.

Economics

An economic assessment of finishing continental steers on high concentrates is shown in Table 34. It is assumed that the animals qualify for the slaughter premium only at £42 head (i.e. both special beef premia have already been drawn and they are not eligible for extensification). If the initial value of the cattle exceeds £100/100kg, then it is very difficult to make a worthwhile margin unless there is a sizeable carcass premium or concentrates are very cheap. Once the initial value of the animals falls below £100/100kg, then there is a prospect of making a margin even at current carcass and concentrate prices.

Table 34. Economic evaluation of high concentrate finishing of steers – net margin (£/head)

	Initial value (£/100kg)		
Carcass price (p/kg)	80	100	120
180	43	-61	-165
200	113	9	-95
220	183	79	-25

Assumptions: Continental steer (initial liveweight 520kg) fed for 90 days, slaughter weight 640kg, carcass weight 350kg, concentrates consumed 1.035t, concentrate price £130/t, silage costs £8/head, non feed costs £20/head, overheads £50/head.
Sensitivity: £10/t concentrate changes margin per head by £10.5; 10% change in gain at constant feed intake changes margin per head by £16 at a carcass price of £2/kg.

Ration Type

Most experiments on high concentrate feeding have been based on barley because of its consistent quality. However, similar results have been obtained with other feeds. Various beet pulp (unmolassed) rations were compared with barley for finishing Friesian steers (Table 35). All the pulp-based rations were similar to the barley-based ration. Furthermore, there was no response to adding soyabean meal to pulp and specially formulated pulp-based beef nuts had no advantage over the "straight" pulp. However, it should be noted that these steers were fairly mature and had some compensatory growth potential. Their daily liveweight gain equalled that of the Charolais crosses described earlier but their carcass gain was somewhat less because of their lower kill-out.

Table 35. Friesian steers finished on different concentrate rations.

	Barley / Soyabean	Beet pulp / Soyabean	Beet pulp only	Beef Nuts[1]
Feed intake(kg / d)[2]	12.7	12.2	12.9	12.6
Liveweight gain (kg / d)	1.46	1.50	1.48	1.52
Carcass (kg / d)	0.92	0.93	0.92	0.93
Efficiency (kg / kg)				
Liveweight	8.7	8.2	8.7	8.3
Carcass	13..8	13.1	13.9	13.6

[1]Beet pulp based.
[2]All feeds adjusted to 875 g / kg dry matter

A comparison of barley and gluten is shown in Table 36. Light (352kg) Friesian steers were fed either all barley (plus soyabean meal), all gluten or one-third of one plus two-thirds of the other for a 140 day finishing period. As the proportion of gluten in the diet increased, intake increased and was 14% higher for all gluten than for all barley. Liveweight gain was similar for all treatments but efficiency was poorer for the gluten. It was estimated that the relative energy value of gluten was 86% that of barley for high concentrate finishing.

Table 36. Comparison of gluten and barley for finishing beef cattle.

	Gluten	Gluten / Barley[1]	Barley / Gluten[1]	Barley
Feed intake (g / kg liveweight)	24.5	24.3	22.0	21.5
Relative intake (Barley = 100)	114	113	102	100
Liveweight gain(kg)[2]	1.83	1.94	1.84	1.85
Feed DM to liveweight (kg / kg)	6.46	6.12	5.78	5.58
Relative energy value	86	91	97	100

[1]2:1 ratio;
[2]High values because animals were implanted twice with anabolic agents.

Most other experiments put the value of gluten higher than this although still less than barley. (The high liveweight gains in this experiment were due to the fact that the animals were implanted twice with anabotic agents. A non-implanted control group fed barley/soyabean had similar feed intake to the corresponding implanted group and had a liveweight gain of 1.49kg/day v. 1.85kg/day for the 4 implanted groups). That animals increase their intake when the energy concentration of the feed declines (as happened here with gluten) is widely recognised. Thus, once the feed is palatable, of good quality and has no anti-nutritional factors, it is not necessary that it be of very high energy concentration for all concentrate finishing. Within limits, animals will increase their intake of a lower energy feed in order to maximise their energy intake.

Table 37. Comparison of barley and maize, and barley and wheat in high concentrate diets.

	Barley[1]	Maize	Barley[2]	Wheat
Feed intake (kg/day)	7.5	7.4	6.1	5.9
Daily gain (kg)	1.25	1.24	1.49	1.42
Efficiency				
Feed to liveweight	6.0	5.9	4.1	4.2
Feed to carcass	9.0	10.0	-	-

[1]Friesian bulls fed for 8 months

[1]Charolais x Friesian bulls fed from 187kg to slaughter.(Puller, 1995, Animal Science 60:49-54)

Although both maize and wheat have higher energy values than barley for poultry and monogastric animals, and are also given higher energy values in ruminant feeding tables this is not supported by animal production experiments on high concentrate feeding. In a "barley beef" experiment at Grange, barley and maize were compared over an 8 month feeding period and no differences were observed in feed intake or daily gain (Table 37). Neither were there any differences in slaughter or carc ass traits. Similarly in Britain, Charolais x Friesian young bulls were fed from 187kg liveweight to slaughter on either barley or wheat with rapeseed meal as a protein source. Overall performance was excellent and similar in every respect for the two cereals.

In conclusion, high concentrate finishing is simple to operate and the results are predictable. A wide range of feeds can be used including cheap pulps and by-products of high quality. Within limits, animals will adjust their intake to the quality of the feed and thereby maintain a high level of performance. All else being equal, high concentrate finishing results in carcasses which are somewhat less fat than those conventionally finished on silage plus concentrates. Nevertheless, it is necessary to be vigilant as animals can quickly get overfat on all concentrates. The main problem with high concentrate finishing is the high cost and it is only profitable when the initial value of the animal is low, concentrate costs are low, or there is a sizeable carcass premium.