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Effect of dietary crude protein level on the performance of cereal fed Holstein bulls

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TRIAL REPORT B35

Trial carried out for EBLEX

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Summary

Cereal fed Holstein bulls weighing 280kg were reared through to slaughter at Harper Adams University College on rations containing 12%, 14% and 16% crude protein (as fed).

Overall the bulls recorded performance that either achieved or exceeded recognised targets for cereal beef production, recording DLWG's of 1.32-1.34kg to slaughter weights of 542-557kg at 13.4-13.8 months old

There were no significant differences in DLWG, carcase daily gain, slaughter weight or carcase weight between the treatments. It is noted that highest the slaughter and carcase weights were achieved by the bulls fed the 12% ration however this was not statistically significant.

The bulls reared on the 12% diet recorded the highest margin over feed costs and highest gross margin per bull. Reducing the protein content of the ration from 16% to 12% increased the gross margin per bull by 10.2% (£7.60 per bull).

From the experiment it can be concluded that increasing the protein content of the ration above 12% for 280kg bulls does not improve physical or financial performance.

Effect of dietary crude protein level on the performance of cereal fed Holstein bulls

1.1 Introduction

According to Allen (1990) a diet based on rolled barley with a protein supplement to give an overall crude protein (CP) level of 14% (as fed) should be offered to bulls from 100kg to 250kg. From 250kg through to slaughter the diet can contain 12% CP. However, Allen asserts that the rate of lean meat gain in continental cross Friesian bulls is so high that there is a strong argument for maintaining the CP content of the overall ration at 14% through to slaughter.

Research in the 1980's showed no response in bulls over 250kg to increasing protein levels above 13% (NAC, 1988; ADAS, 1985; Rigby and Lodge, 1989). These trials involved bucket reared bulls, mainly pure Friesians, whereas in a trial comparing 10, 12 and 14% CP by Jacklin and Rigby (1990) a significant response in performance with increased protein content was recorded however this work was conducted with weaned Charolais cross suckled bulls. On the low protein diets (10%) feed intake fell with a corresponding reduction in live weight gain so that the bulls entered a 'store period'.

Anderson *et al.,* (1988) compared diets containing 10, 12 and 14% CP with 333kg Angus and Hereford bulls. Bulls given 10% CP grew more slowly ($P<0.05$) than bulls given 12 or 14% CP. Bulls given 12% CP had fatter carcasses ($P<0.05$) than bulls given 10 or 14% CP. It must be noted that this study was carried out with early maturing beef breeds. In an additional experiment 318kg Simmental crossbred bulls were also fed 10, 12 or 14% CP diets. Bulls given 10% CP had lower ($P<0.05$) rates of carcass protein accretion during days 0 to 136 and days 0 to 202. Daily live weight gain and slaughter weights were not reported.

When 'proteins are cheap' the recommendation from Lowman and Lewis (1991) are to maintain protein levels of around 170g/kg DM (15% as fed).

There have been a large number of feeding trials carried out in North America on the optimum protein levels for finishing feedlot cattle. These trials however involved finishing early maturing breed type suckler bred beef steers fed on maize based rations from approximately 350kg to slaughter at 550kg.

Shields, a consultant with Promar, advocates a rearing diet of 16% CP to 250kg live weight. From 250kg to slaughter he advises dropping CP to about 14% (Lawrence 2006). Currently the majority of compound feed manufacturers' market rations containing either 15% or 16% CP for intensively fed bulls. However the majority of intensively fed beef cattle are fed home mix rations based on rolled barley with a protein concentrate or 'protein rich' straights such as rapeseed meal and soya bean meal. In this latter situation higher protein rations will have increased ration costs.

There is a paucity of data on the optimum crude protein content of cereal

based diets for late maturing beef cattle, particularly Holstein bulls and Continental cross Holstein bulls. The objective of this experiment was therefore to determine the effect of feeding rations containing either 12%, 14% or 16% dietary crude protein (as fed) on the performance of cereal fed 280kg Holstein bulls through to slaughter.

1.2 Materials and Method

The trial started on the 24th of April 2007 with forty eight September/October 2006 born Holstein bulls weighing approximately 280kg at 7 months old.

The calves involved in the trial were sourced from the Harper Adams University College dairy herd. Prior to commencement of the trial the calves were fed a proprietary 16% CP intensive beef nut (Wynnstay Prime Beef) *ad libitum*. The treatment rations were gradually introduced over a 14 day period.

Sixteen bulls were allocated according to live weight into the following treatments, with two pens of bulls per treatment:

1. 12% CP
A*d libitum* 120g crude protein/kg (12% CP as fed) barley based concentrates.

2. 14% CP
A*d libitum* 14% CP (as fed) barley based concentrates.

3. 16% CP
A*d libitum* 16% CP (as fed) concentrates.

See table 1 for details of the formulation of the rations.

Table 1 *Feed rations*

	Crude Protein		
Feeds (kg/t)	**12%**	**14%**	**16%**
Rolled Barley @ £95/t	755	690	630
Soya @ £165/t	37.5	70	100
Rape @ £105/t	37.5	70	100
Beet Pulp @ £107/t	100	100	100
Molasses @ £95/t	50	50	50
Int Beef Mins @ £250/t	20	20	20
£/tonne (inc £5/t mill & mix)	**107.30**	**109.90**	**112.30**

Four samples of each beef mix were analysed by NIR (Rumenco Ltd, Stretton House, Burton-on-Trent, Staffs, DE13 0DW). Table 2 details the results.

Table 2 *Ration analyses*

Values as fed unless stated	12%	14%	16%
Moisture %	16.2	16.4	15.5
Oil B %	2.0	1.4	1.6
Protein %	12.2	13.9	16.1
CP % of DM	**14.5**	**16.6**	**19.1**
Fibre %	6.7	5.1	5.6
Ash %	7.1	6.7	7.2
Starch %	37.3	36.2	34.2
Sugar %	6.8	5.6	6.4
NCGD % (DM)	86.2	85.7	85.1
NDF %	10.3	10.9	12.0
ME (MJ/kg DM)	12.7	12.4	12.4

The cattle were housed in straw-bedded pens (9.8m x 4.6m) with access to water and *ad libitum* barley straw from racks.

The bulls were weighed at the start, at 30 day intervals and at slaughter. They were 'double weighed' at the start and at slaughter. The cattle were reared through to slaughter at fat class 3. Fat classification was subjectively assessed by Mr. Simon Marsh in conjunction with Mr. David Ferguson, Senior Technician at Harper Adams University College. All of the cattle were slaughtered at Anglo Beef Processors Ltd. (ABP) at Shrewsbury using the New EC dressing specification. Slaughter live weight was recorded prior to being loaded on the cattle wagon. The journey from Harper Adams to ABP takes about 30 minutes and the cattle were slaughtered within approximately 1 hour of delivery at ABP.

1.3 Results

Animal performance
Carcase weight at the beginning of the experiment was estimated by assuming a dressing proportion of 0.47 (Patterson *et al.,* 1995). Details of the carcase classification scoring system and carcase pricing structure are shown in appendix 1. The data was analysed using ANOVA with DLWG calculated by difference from birth to slaughter.

Table 3 *Animal performance*

	12%	14%	16%	s.e.d	Sig
Start wt (kg)	283.7	280.6	269.9	14.91	NS
Slaughter wt (kg)	556.7	548.9	541.7	11.16	NS
Days on trial	205.6	205.0	206.4	11.09	NS
DLWG (kg)	1.341	1.322	1.328	0.0538	NS
Age at slaughter (months)	13.78	13.54	13.37	0.354	NS
Carcase wt (kg)	284.1	280.1	277.6	5.73	NS
Carcase daily gain (kg)	0.741	0.731	0.737	0.0283	NS
Kill out (g/kg)	510	510	513	0.46	NS
Conformation class	2.00	2.08	2.00	0.157	NS
Fat class	3.17	3.08	3.17	0.228	NS
Carcase price (p/kg)	176.4	177.6	176.4	2.92	NS
Live weight price (p/kg)	90.5	90.6	90.4		
Carcase value (£)	503.7	497.4	489.8	13.77	NS

NS = not significant

There were no significant differences in performance between the treatments. It can be noted that the bulls fed on the 12% diet recorded the heaviest carcase weight and were slaughtered slightly older however none of these differences were statistically different.

Feed intakes
Feed intakes were recorded on a ‘group basis’ from the start of the trial and were recorded through to slaughter and are shown in table 4. Feed conversion ratio (FCR) was estimated and feed cost per kg gain calculated based on the costs of the rations (see table 1 for ration costs).

Table 4 *Feed use, Estimated FCR and Feed cost per kg gain*

	12%	14%	16%
Daily feed intake (kg)	9.22	8.90	8.89
Total feed intake (kg)	1,895	1,825	1,834
FCR (kg feed: kg LWG)	6.94	6.80	6.75
FCR (kg feed: kg Carcase gain)	12.57	12.31	12.17
Feed cost (p/kg LWG)	74.5	74.7	75.8
Feed cost (p/kg Carcase gain)	134.5	135.2	136.7

The bulls reared on the 12% diet recorded slightly higher daily feed intakes and the worst FCR. However due to the lower cost of the 12% ration they recorded the lowest feed cost per kg gain. The differences in feed cost per kg gain were nevertheless relatively small between the treatments.

The FCR's appear to be relatively poor at 6.75-6.94. It must be noted that the trial did not include the period of growth from 120kg to 280kg. During this rearing phase Holstein bulls at Harper Adams typically record a DLWG of

1.75kg with an FCR of 3.2.

Shown in appendix 2 are the gross margins and physical performance data for the bulls reared from calves which recorded an overall of FCR of 5.11 from birth to slaughter. The data also shows the performance of a batch of Simmental x Holstein bulls that were reared alongside the Holsteins.

Financial appraisal
Margin over feed and a gross margin per bull was calculated based on the prices prevailing at the time of the study and are shown in tables 5 and 6.

Table 5 *Margin over Feed (£/bull)*

	12%	**14%**	**16%**
Sale of carcase	503.7	497.4	489.8
Feed cost/bull	203.3	200.6	206.0
Margin over Feed	**300.4**	**296.8**	**283.8**

The bulls reared on the 12% diet recorded the highest margin over feed which was £3.60 and £16.60 per bull greater than the 14% and 16% diets respectively. It must be noted however that the bulls on the 16% ration had a lower start weight which influences this method of financial appraisal.

Gross margins were therefore calculated based on a valuation of the bulls at the start of the experiment of 65p/kg live weight. As shown in table 6 the bulls fed the 12% diet recorded a £1.60 and £7.60 per head higher gross margin compared to the 14% and 16% fed bulls respectively.

Table 6 *Gross Margins (£/bull)*

	12%	**14%**	**16%**
Output			
Sale of carcase	503.7	497.4	489.8
Variable & Stock Costs			
Stock purchase @ 65p/kg	184.4	182.4	175.4
Concentrates	203.3	200.6	206.0
Veterinary	3	3	3
Bedding	13	13	13
Other costs	17	17	17
Total variable costs	420.7	416.0	414.4
Gross Margin	**83.0**	**81.4**	**75.4**

Reducing the protein content of the ration from 16% to 12% increased the gross margin per bull by 10.2%.

1.4 Discussion and Conclusions

Overall the bulls recorded performance that either achieved or exceeded recognised targets for cereal beef production. The MLC (not dated) target for cereal fed Holstein-Friesian bulls are a DLWG of 1.3kg (from 3 months old to slaughter) and carcase weight of 250kg classifying -O/P+3 at 11.5 months old.

Targets for Holstein-Friesian bulls recently quoted by EBLEX (2005) are a slaughter weight of 540kg at 13 months old.

Growth rates, slaughter weights and feed intakes
There were no significant differences in DLWG, carcase daily gain, slaughter weight or carcase weight between the treatments. It is noted that highest the slaughter and carcase weights were achieved by the bulls fed the 12% ration however this was not statistically significant. It has been suggested that feeding a higher protein ration could increase slaughter weight or help produce leaner carcasses but this was not evident from this trial. The excess protein from the 14 and 16% diets would have to be converted to urea by the rumen micro-organisms, absorbed across the rumen wall and excreted in the urine. This will demand energy which would otherwise be used for growth.

The bulls fed the 12% ration recorded the highest daily and total feed intake and the worst FCR however it is likely that these differences would not be statistically significant.

Carcase characteristics, price (p/kg) and value
There were no significant differences in killing out percentage, conformation or fat class score. The overall classification equated to a -O3 grade. There were no significant differences in carcase price (p/kg) or value. Due to the higher carcase weight of the bulls fed the 12% ration the value of the carcase was increased by £13.90 compared to the bulls fed the 16% ration however this was not statistically significant.

Economic assessment
The bulls reared on the 12% diet recorded the highest margin over feed costs and highest gross margin per bull. Feed prices change on a daily basis and at the time of writing the ration costs have increased from £107-£112/t to £165-£180/t. However it is pleasing to comment that the finished beef price for -O3 grade black and white bulls has increased from £1.75/kg to £2.48/kg.

The diets in the experiment were based on feeding rolled barley with protein from soya and rapeseed meal. These latter two feedstuffs are always significantly higher in price compared to rolled cereals so therefore increasing the protein content of the diet increases the cost of the ration. With no significant improvement in performance with the increased protein content this resulted in lower gross margins being recorded.

The majority of intensive cereal fed bulls in the UK are fed diets based on rolled barley however there are a significant number of bulls fed on proprietary compounded feeds and due to the raw materials typically sourced and used within ‘Intensive Beef Nut’ formulations Steve Brown comments that it is unlikely that reducing the protein content of the diet will reduce the cost of the ration (2008. Pers.Comm. Mr. S.T. Brown is the Ruminant Technical Manager for Wynnstay Group plc).

From the experiment it can be concluded that increasing the protein content of the ration above 12% for 280kg bulls does not improve physical or financial

performance.

North American trial results
In his review of the work conducted on protein levels in North America involving over 50 trials finishing suckler bred beef steers fed on maize based rations Lewis (2004) concluded the following:

- "Where high and low protein levels were compared, these were usually **11% and 13% on a dry matter basis**. These are equivalent to about **9.5% and 11.5% on a fresh weight basis** which are substantially lower than levels fed on most UK farms
- Average DLWG for 11% diets was 1.43kg compared to 1.53kg for diets with 13% protein
- A few trials showed that performance was poorer with diets containing over about 15% protein (approx 13% as fed). This was attributable to lower intakes and the energy cost to the animal getting rid of the excess protein."

The results from this experiment concur with the review by Lewis.

1.6 Future work

In view of the recent increase in price of cereals and also since it is recognised that bull beef production is considered to be the most appropriate system for Holstein calves, work should therefore be conducted on the replacement of cereals with high energy forages such as maize silage and 'head cut' cereals to achieve the target carcase weight of 280kg at 13 months old.

1.7 Acknowledgements

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Signed: _____

Mr. S P Marsh
On behalf of Harper Adams University College

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1.8 References

ADAS (1985). *Protein levels and slaughter weight for cereal fed Friesian bulls.* Report of Field Trials, 1985, HMSO, London

Allen, D. (1990). *Planned Beef Production and Marketing.* BSP Professional Books, London.

Anderson, P.T., Bergen, W.G., Merkel, R.A. and Hawkins, D.R. (1988). The effect of dietary crude protein level on rate, efficiency and composition of gain of growing beef bulls. *Journal of Animal Science.* **66,** 8, 1990-1996

EBLEX Beef Action for Profit 3 (2005) Better Returns from Dairy-Bred Bulls. *Meat and Livestock Commission.*

Jacklin, D. and Rigby, I. (1990). Effect of protein supplementation on the performance of intensively fed weaned suckled bulls. *Animal Production* **50,** 579

Lawrence, C. (2006). Faster dairy bull growth can safeguard profits in SFP era. *Farmers Weekly,* February, 25.

Lewis M. (2004). *Protein levels in diets for intensively finished beef.* Promar International. (Sheep & Beef Notes, March 2004)

Lowman, B.G and Lewis, M. (1991). The Feeding and Management of Intensively Reared Bulls: Conventional Compared with Organic*. Recent Advances in Animal Nutrition.* 181-209

MLC (not dated) Beef Management Matters No.1: Bull Beef: Costings and Production Systems.

National Agricultural Centre (1988). High protein diets for Continental cross bulls in cereal beef*. Beef and Calf Unit Newsletter*, **28,** 4

Patterson, D.C., Steen, R.W.J. and Kilpatrick, D.J. (1995). Growth and development in beef cattle. 1. Direct and residual effects of plane of nutrition during early life on components of gain and food efficiency. *Journal of Agricultural Science,* **124,** 91-100

Rigby, I. and Lodge, N. (1989). The response of intensively finished dairy bred bulls to three levels of protein. *Animal Production,* **48,** 656

1.9 Appendix 1

Carcase classification and pricing structure

Conformation and fat class scores were converted from the MLC beef carcase classification scale to a numerical scheme as shown below:

Conformation:		> Improving Conformation >				
MLC System	P+	-O	O+	R	-U	U+	E
Harper Adams System	1	2	3	4	5	6	7
Carcase Price* (£/kg):						
Bulls	1.60	1.75	1.98	2.08		

Fat Class:	> Increasing Fatness >						
MLC System	1	2	3	4L	4H	5L	5H
Harper Adams System	1	2	3	4	5	6	7
Carcase Price (p/kg)		Base*	Base*	Base*	-6		

* Carcase price at fat class 2, 3 and 4L

1.9.1 Appendix 2

Harper Adams University College Beef Unit

Gross Margins for Holstein & Simmental x Holstein bulls - 2006/2007

System: Intensive Cereal Beef

Financial Performance (£/bull)	Holstein	Simmental x
Output		
Sales	497	660
Less calf purchase	25	136
Total Output	472	524
Variable Costs		
Calf rearing to 3 months	54	54
Finishing concentrates	264	262
Vet & medicines	6	6
Bedding & other costs	35	36
Total variable costs	375	375
Gross Margin/Head	**113**	**166**
Physical Performance		
Age at slaughter (months)	13.56	13.83
Birth wt (kg)	43	45
Wt at slaughter (kg)	549.1	579.6
DLWG (kg from birth)	1.224	1.267
Carcase wt (kg)	280.6	322.3
Daily carcase gain (kg)	0.633	0.715
Killing out %	51.1	55.6
Carcase class*	2.0	3.7
Fat score*	3.2	3.2
Feeds (kg)		
Milk replacer @ £1,200/t	23	23
Calf concentrates @ £157/t	166	170
Finishing concentrates @ £110/t	2399	2386
FCR (kg feed/kg gain)	5.11	4.82
FCR (kg feed/kg carcase gain)	9.94	8.56
Prices		
Sale price (£/kg live weight)	0.91	1.14
Sale price (£/kg carcase weight)	1.77	2.05

* EUROP carcase classification: Conformation: P+=1 and E=7, Fat class: 1=1 and 5H=7.