



**ANIMAL SCIENCE RESEARCH CENTRE**

**Effect of reducing the starch content of cereal based rations  
by the partial replacement of barley with soya hulls for  
intensively finished dairy-bred bulls**

**TRIAL REPORT B49**

**FOR EBLEX**

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## Executive Summary

Forty-eight dairy-bred bulls (42 Holstein and 6 Beef cross Holstein) weighing 300kg were reared through to slaughter and fed *ad libitum* cereal based rations with either a high (42% in DM, 36% as fed), standard (37% in DM, 32% as fed) or medium (30% in DM, 26% as fed) starch content. The rations were based on rolled barley, with either 10% or 20% of barley replaced with soya hulls. The rations were formulated to contain 165g crude protein/kg DM (14%CP as fed) with the inclusion of soyabean meal, rapeseed meal, molasses and minerals.

Overall bull performance was satisfactory with the Holsteins recording slaughter weights of 566kg at 14.0 months old.

The High starch fed bulls recorded significantly higher ( $P<0.05$ ) slaughter weights (574 v 561 v 564kg) compared to the Standard and Medium starch fed bulls. The High starch fed bulls also recorded numerically higher daily live weight gains and carcase weights however they were not statistically significantly different. There were no differences in carcase characteristics or liver scores.

The High starch fed bulls recorded the best FCR (6.93, 7.29 and 7.37:1 kg feed: kg gain respectively for the High, Standard and Medium starch treatments). The FCR of 6.93:1 (fresh weight) for the High starch fed bulls appears relatively high but it must be taken into consideration that the trial did not include the period of growth from 110kg to 300kg. During this rearing phase dairy-bred bulls at Harper Adams University typically record DLWGs of 1.52kg with an intake of 625kg of feed with an FCR of 3.3:1.

The highest margin over feed was recorded with the High starch fed bulls which was £17 (2.9%) and £13 (2.2%) more than the Standard and Medium starch mixes respectively.

The replacement of some barley with soya hulls increased the feed costs per kg carcase gain by 3.6% (9p).

## Farmer Recommendation

- From this study optimum performance with barley based rations with intensively finished dairy-bred bulls was recorded with rations containing 42% starch in the DM (36% as fed).

## 1.0 Introduction and Objectives:

It is acknowledged that starch is the key nutrient driver to optimise daily live weight gain (DLWG) with intensive finishing systems for beef cattle. This was confirmed in a study (Marsh & Brown, 2007) to compare the performance of bulls fed diets with either a high (38.3% starch in DM) or low (9.3%) level of starch in a proprietary beef nut. The bulls fed the proprietary beef nut with the high starch content recorded significantly higher slaughter weights, DLWG's and carcass weights. There was also a reduction in the number of days to slaughter and an improvement in feed conversion ratio (FCR) and conformation score. Based on the costs prevailing at the time of the study, gross margins were increased by £96 per head with feeding the high starch ration.

Recent beef feeding trials at Harper Adams University have included recording liver damage scores. Liver abscesses are associated with mild acidosis from feeding high starch based diets (Plaizier *et al.*, 2009) and it could therefore be assumed that reduced rumen acidosis should result in improved performance. Intensively fed cattle are traditionally fed diets based on rolled barley and a typical ration would often include 75-85% barley and therefore contain 40+% starch in the DM (34+% as fed). In a recently completed study to evaluate crimped grain maize against rolled barley at Harper Adams bulls fed crimped grain maize, which has a significantly higher by-pass starch content than barley, recorded significantly lower liver damage scores and improved performance (Marsh *et al.*, 2011). Unfortunately grain maize can only be reliably grown in Southern England and grown in the Midlands under plastic which significantly increases production costs.

In an experiment to evaluate moist co-product feeds (blend of Traffordgold, bread and beet pulp) against a conventional ration based on rolled barley there was a significant reduction in liver damage scores and increase in slaughter weight with the moist co-product ration (Marsh *et al.*, 2011). The starch contents of the co-product and barley rations were 30% and 37% in the DM respectively. Unfortunately there is a limited supply of co-products in the UK and feeders of co-products need appropriate storage and handling facilities such as a feeder wagon, materials handler and clamps.

The objective of the following study was to investigate the partial substitution of barley with soya hulls to evaluate different starch contents of intensive beef finishing diets. Soya hulls have a significantly lower starch content than rolled barley, similar crude protein content, higher NDF and lower ME value. Further details of the feed value of barley and soya hulls are shown in appendix 1. The replacement of some barley with soya hulls would therefore reduce the starch content and increase the NDF content of intensive beef finishing rations. Soya hulls have a similar feed price to rolled barley and are readily available. Alternatives to soya hulls are molassed sugar beet pulp and citrus pulp.

## **2.0 Materials & Method**

### **2.1 Location**

Harper Adams University Beef Unit, Newport, Shropshire, TF10 8NB.

### **2.2 Animals & Timing**

The trial commenced on the 28<sup>th</sup> of May 2012 with forty-eight September to October 2011 born dairy-bred bulls weighing approximately 300kg at 7 months old. There were 42 Holstein, 3 Continental cross Holstein bulls and 3 Angus cross Holstein bulls.

### **2.3 Treatments**

The bulls were allocated in a randomized block design according to live weight and breed into the following feeding treatments with sixteen bulls per treatment. Prior to commencement of the trial the calves were fed *ad libitum* 'Harper Adams 14% CP' barley beef ration (see appendix 2 for formulation). The treatment rations were gradually introduced over a 10 day period.

#### **1. High starch (42% Starch in DM, 36% as fed)**

*Ad libitum* 165g crude protein/kg DM (14% CP as fed) concentrates based on rolled barley.

#### **2. Standard starch (37% Starch in DM, 32% as fed)**

*Ad libitum* 14% CP concentrates based on rolled barley including 10% soya hulls.

#### **3. Medium starch (30% Starch in DM, 26% as fed)**

*Ad libitum* 14% CP concentrates based on rolled barley including 20% soya hulls.

Details of the above ration formulations, predicted analysis, declared nutrient values and mineral specification used in the concentrates are shown in appendix 3. The majority of manufactured compounded intensive beef feeds would contain a similar starch content to the Standard starch ration and contain 14% CP. The rations were analysed by Near Infrared Reflectance Spectroscopy (NIR) and the results shown in table 1.

**Table 1: Feed analysis results**

Feed analysis (% as fed)	High Starch	Standard Starch	Medium Starch
Dry Matter (%)	84.1	85.1	85.9
Oil B (%)	2.8	2.3	2.3
Ash (%)	5.9	5.6	7.4
Crude Protein (%)	14.3	14.0	13.9
Crude Fibre (%)	5.4	9.3	13.3
NDF (%)	16.0	27.5	34.6
Starch (%)	36.1	31.8	25.7
Starch (% in DM)	42.9	37.4	29.9
ME (MJ/kg DM)	12.9	12.9	12.8

As expected the rations containing soya hulls had a higher fibre and lower starch content. All rations had similar ME concentrations.

## **2.4 Management**

The cattle were group housed in straw-bedded yards with 2 pens of bulls per treatment and had free access to straw from racks. The rations were fed *ad libitum* via hoppers (see plate 1).



*Plate 1: The Harper Adams University beef unit*

The bulls were 'double weighed' at the start of the trial and at slaughter. They were selected for slaughter at EU fat class 3 by Simon Marsh (Senior Lecturer – Beef Cattle Specialist). All of the cattle were slaughtered at Anglo Beef Processors Ltd (ABP) at Shrewsbury using the UK dressing specification.

### 3.0 Results and Discussion:

Overall bull performance was satisfactory with the Holsteins recording slaughter weights of 566kg and carcass weights of 291kg at 14.0 months old compared to the EBLEX (2012) target of 540-600kg (270-300kg carcass) at 14 months old. Further details of the physical and financial performance of the Holstein, Continental cross Holstein and Angus cross Holstein bulls are shown in Appendix 4. The data was analysed using ANOVA with start weight as a co-variate. Liver scores were analysed using Kruskal-Wallis analysis of variance.

#### 3.1 Liveweight and days to slaughter

As shown in table 2 the High starch fed bulls recorded significantly higher ( $P<0.05$ ) slaughter weights compared to the Standard and Medium starch fed bulls. DLWG was calculated by the difference from slaughter weight to start weight. Reducing the starch content of the barley mix with soya hulls resulted in lower DLWGs but this was not statistically significant.

**Table 2: Animal performance (kg/bull)**

(Kg/bull)	High Starch	Standard Starch	Medium Starch	s.e.d	Sig
Start wt	299	298	299	1.5	NS
Slaughter wt	574 <sup>a</sup>	561 <sup>b</sup>	564 <sup>b</sup>	4.8	*
Days to slaughter	197	194	197	5.0	NS
DLWG	1.41	1.37	1.35	0.044	NS

Within row, means with the same superscript are not significantly different ( $P>0.05$ )  
NS = not significant, \* =  $P<0.05$ , \*\* =  $P<0.01$ , \*\*\* =  $P<0.001$

It was observed that there was no difference in coat bloom at slaughter. This however was not assessed to quantify this statement.

#### 3.2 Carcass characteristics

Carcass characteristics are illustrated in table 3. Killing out percentage appears relatively low however it must be noted that the majority of the bulls were Holsteins; they were weighed 'gut full' prior to slaughter and the carcasses were trimmed to UK specification. The High starch fed bulls recorded a higher ( $P = 0.163$ ) carcass weight compared to the bulls fed mixes with soya hulls.

**Table 3: Carcase characteristics**

	High Starch	Standard Starch	Medium Starch	s.e.d	Sig
<b>Carcase wt (kg)</b>	297	291	292	3.4	=0.163
<b>Kill out (%)</b>	51.5	51.8	51.8	0.34	NS
<b>Carcase DG (kg)</b>	0.80	0.78	0.77	0.025	NS
<b>Conformation<sup>1</sup> (1-7)</b>	2.3	2.3	2.4	0.16	NS
<b>Fat class<sup>1</sup> (1-7)</b>	3.3	3.5	3.4	0.18	NS
<b>Liver score<sup>2</sup> (1-5)</b>	1.23	1.11	1.08	0.129	NS

<sup>1</sup> EUROP carcase classification: Conformation: P+=1 and E=7, Fat class: 1=1 and 5H=7.

<sup>2</sup> See appendix 5 for Liver Assessment Scores

There were no differences in conformation and fat classification scores.

The carcasses graded relatively very well for dairy-bred bulls with the majority of the Holstein grading -O. Of the 42 Holstein bulls, 15.6% graded O+, 84.4% graded -O, with no bulls recording P+ grades.

There were no significant differences in liver scores. The High starch fed bulls might have been expected to record higher liver damage scores since liver abscesses are associated with mild acidosis from feeding high starch based diets (Plaizier, 2009). This was not recorded in this experiment and thus contrary to what could have been predicted.

### 3.3 Feed intakes

It can be seen from table 4 that reducing the starch content of the rations with soya hulls increased total and daily concentrate feed intake and with no improvement in DLWG resulted in a deterioration of the FCR.

**Table 4: Feed intakes and Feed Conversion Ratio (FCR)**

	High Starch	Standard Starch	Medium Starch
<b>Total concentrate intake (kg)</b>	1,907	1,918	1,932
<b>Daily concentrate intake (kg)</b>	9.68	9.89	9.81
<b>FCR (kg feed: kg gain)</b>	6.93	7.29	7.37
<b>FCR (kg feed: kg carcase gain)</b>	12.10	12.68	12.74
<b>FCR (kg feed DM: kg gain)</b>	5.83	6.20	6.33
<b>FCR (kg feed DM: kg carcase gain)</b>	10.18	10.79	10.94

<sup>1</sup> FCR calculated on a feed fresh weight basis.

The FCR of 6.93:1 (fresh weight) for the High starch fed bulls appears relatively high but it must be taken into consideration that the trial did not include the period of growth from 110kg to 300kg. During this rearing phase dairy-bred bulls at Harper Adams typically record DLWGs of 1.52kg with an intake of 625kg of feed with an FCR of 3.29:1. Overall feed intakes from 12 weeks old to slaughter were 2.5-2.6t (fresh weight) per bull.



### 3.4 Financial appraisal

The cost of the rations were calculated based on the feed costs prevailing at the time of the study and are shown in table 5.

**Table 5: Ration formulation and costs**

Feeds (kg/t)	High Starch	Standard Starch	Medium Starch
Barley @ £172/t	785	675	575
Soya Hulls @ £165/t		100	200
Rapeseed meal ext @ £245/t	70	70	70
Soyabean meal @ £374/t	70	70	70
Molasses Blend @ £155/t	50	50	50
Minerals @ £350/t	25	25	25
£/t	194.85	192.43	191.73
Plus £10/t mill & mix costs	204.85	202.43	201.73

Notably substituting barley with soya hulls had very little effect on ration cost per tonne because both feeds had a similar price

Margin over feed and feed costs per kg gain were calculated. Details of the carcass prices on a £/kg basis were standardised for the various carcass grades and are shown in appendix 6.

From the results shown in table 6 the highest margin over feed was recorded with the High starch fed bulls which was £17 (2.9%) and £13 (2.2%) more than the Standard and Medium starch rations respectively. If the bulls were fed on a High starch ration from 3 months of age and assuming that they performed at the same level as recorded in this study then they would return a significantly higher margin.

The replacement of barley with soya hulls increased the feed costs per kg carcass gain by 3.6% (9p) because of reduced animal performance.

**Table 6: Financial performance**

	High Starch	Standard Starch	Medium Starch	s.e.d	Sig
Carcass price (£/kg)	3.34	3.34	3.35	0.024	NS
Carcass value (£)	992	972	978	15.6	NS
Feed cost (£/t)	204.85	202.43	201.73		
Feed cost (£/bull)	391	388	390		
Margin over Feed (£/bull)	601	584	588		
Feed cost/kg live wt gain (£/kg)	1.41	1.46	1.47		
Feed cost/kg carcass gain (£/kg)	2.48	2.57	2.57		

#### **4.0 Conclusions:**

- Overall performance of the bulls was satisfactory achieving similar results to the EBLEX (2012) targets for intensive cereal beef production.
- The High starch fed bulls recorded significantly higher ( $P < 0.05$ ) slaughter weights compared to the Standard and Medium starch fed bulls.
- The High starch fed bulls recorded a highest DLWG but this was not significantly different.
- The High starch fed bulls recorded higher ( $P = 0.163$ ) carcass weights compared to the Standard and Medium starch fed bulls.
- There were no significant differences in carcass characteristics or liver damage scores.
- Daily concentrate feed intakes were lowest for the High starch treatments which subsequently recorded the best FCR.
- Based on the costs prevailing at the time of the study the highest margin over feed was recorded with the High starch fed bulls which increased by 2.2-2.9% compared to the lower starch diets.
- Diets of up to 42% starch in the DM did not cause signs of liver damage in bulls finished on intensive barley based rations

As concluded above the reducing the starch content of barley based rations by replacing 10% to 20% of barley with soya hulls had a negative effect on cattle performance and margins.

#### **4.1 Recommendations for future study**

A number of beef producers have contacted the author regarding feeding wheat to intensively finished cattle but this is not recommended due to the very high starch content of wheat and the issues of processing wheat grain since it is difficult to 'lightly roll' resulting in cattle being fed 'ground wheat' that would degrade rapidly in the rumen causing acidosis. The inclusion of soya hulls in wheat based rations could overcome the problems with feeding wheat and is worthy of investigation.

## **5.0 Acknowledgements:**

The author would like acknowledge the support from EBLEX for funding the study. He would also like express his sincere gratitude to Steven Feehan and Chris McLachlan at ABP for their assistance with recording the liver scores at the abattoir. The contribution of Daniel Harries who undertook this work as part of his BSc Honours Research Project is also gratefully acknowledged, as is the support of the ruminant technicians at Harper Adams University.

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## Appendix 1

### Feed value of Barley and Soya Hulls

% in DM	Barley	Soya Hulls
ME (MJ/kg DM)	13.2	11.9
Starch	59.0	5.0
Sugar	3.0	3.0
Crude Protein	12.1	12.2
NDF	21.1	67.5
Oil	3.0	2.4

Source: EBLEX. 2008. The Mini Feeds Directory

## Appendix 2

### Harper Adams 14% CP Barley Beef Ration

Feeds	kg/t
Rolled Barley	675
Molassed Beet Pulp	100
Soyabean meal	75
Rapeseed meal	75
Molasses	50
Minerals	25

## Appendix 3

### Trial diets

Feeds (kg/t)	High Starch	Standard Starch	Medium Starch
Rolled barley	785	675	575
Soya Hulls		100	200
Rapeseed meal	70	70	70
Soyabean meal	70	70	70
Molasses	50	50	50
Minerals	25	25	25
Theoretical Analysis			
ME (MJ/kg DM)	12.8	12.7	12.6
Starch (% in DM)	41.6	37.1	30.4
Starch (% as fed)	35.8	31.9	26.1
NDF	21.0	25.7	30.4
Crude Protein (%)	14.0	14.0	14.0
Crude Protein (% in DM)	16.3	16.3	16.3

### Declared nutrient values

% as fed	High Starch	Standard Starch	Medium Starch
Oil	2	2	2
Protein	14	14	14
Fibre	5	8	11
Ash	6	6	6

### Mineral Specification

Calcium (%)	25.3
Phosphorus (%)	1
Magnesium (%)	0.1
Sodium (%)	11.8
Salt (%)	30
Copper (mg/kg)	1,200
Iodine (mg/kg)	200
Selenium (mg/kg)	16
Cobalt (mg/kg)	40
Iron (mg/kg)	2,500
Manganese (mg/kg)	2,000
Zinc (mg/kg)	3,200
Vitamin A (iu/kg)	400,000
Vitamin D3 (iu/kg)	80,000
Vitamin E (mg/kg)	800

## Appendix 4

### Performance results for Holstein and Beef cross Holstein bulls

Breeds adjusted data	Holstein	Cont x Hol	Angus x Hol
Slaughter wt (kg)	566	593	554
Age at slaughter (months)	14.0	14.3	12.8
DLWG from birth (kg)	1.23	1.27	1.32
DLWG from 12 weeks old (kg)	1.33	1.37	1.45
Carcase wt (kg)	291	332	283
Kill out (%)	51.3	55.9	51.2
Carcase DG from birth (kg)	0.62	0.71	0.66
Conformation (1-7)	2.2 (-O)	3.7 (R/O+)	2.8 (O+)
Fat class (1-7)	3.1	3.0	4.3 (4L)
Carcase Price (£/kg)	3.32	3.52	3.44
Carcase Value (£)	964	1167	974
Number of bulls	42	3	3

#### Notes:

Results for the Beef x Holstein bulls must be treated with caution due to the very low number of cattle. They are however 'typical' for Continental and Angus x Holsteins intensively finished

at Harper Adams

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

Kill out appears to be low however it must be noted that the bulls were weighed gut full' prior to slaughter and the carcasses trimmed using UK Specification

## Appendix 5

### Liver assessment scores

Score	Description
5	Severe abscesses
4	Abscesses and/or severe discolouration
3	Slight abscesses, discolouration and/or swelling
2	Minor discolouration/swelling
1	Healthy liver

Livers scores 4-5 would be condemned and hence discarded at the abattoir. Liver score 3 could be trimmed depending on the degree of abscesses, discolouration and/or swelling.



*Plate 2: Liver score 1 (left) and score 5 (right)*

## Appendix 6:

### Carcass prices (£/kg) for bulls sold from October 2012 – December 2012

Conformation class	£/kg @ fat class 3 & 4L
R	3.55
O+	3.45
-O	3.30
P+	3.15
Underweights 260-270kg	-2p/kg
Underweights 250-260kg	-4p/kg