Sustainable protein sources for pregnant ewes

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1 Executive summary

Diets for pregnant ewes generally include some soya bean meal to provide the high quality protein needed to meet digestible undegradable protein (DUP) requirements, and soya is often included in creep feeds for lambs and various other mixes. However almost all soya is imported into the UK from South America and there is a need to evaluate other protein sources that can be grown in the UK to improve the long term sustainability of UK sheep production.

Typically protein sources used in sheep diets include: grass and forage crops, soya bean meal, rapeseed meal, palm kernel, field beans, sunflower seed meal, distillers dark grains and various other products e.g. wheatfeed, maize gluten, malt culms, lucerne, linseed meal etc. Currently about 3% of the soya used in the UK is fed for sheep.

The UK is self-sufficient in rapeseed meal (RSM) and since no GM oilseed rape is currently authorised to be grown in the EU, supplies are GM-free. It is a high-protein feed, typically containing approximately 34% protein, i.e. approximately 75% that of soya bean meal, although the amino acid profile of RSM is higher than that of the majority of other vegetable proteins.

Field beans and peas are good sources of starch and rumen degradable protein. Beans are less palatable than peas although crimping can allow greater inclusion rates by breaking down the anti-nutritional tannins in the bean. Although peas and beans contain tannins and trypsin inhibitors, these are relatively unimportant for ruminants.

Work carried out by ADAS between 1999 and 2002 showed the effectiveness of distillery by-products (maize and barley) with and without beans when compared to rapeseed meal and soya bean meal as supplements to straw based diets for pregnant ewes. More recently two bioethanol plants have opened (2009 and 2010) that together will account for *c.* 2 Mt of wheat per annum processed, and an output of at least 600,000 t wheat distillers dark grains (WDDG) for the animal feed market. WDDG has a relatively high protein content – typically 38-42% in the dry matter - and in crude protein terms this represents approximately 40% of the crude protein supplied by soya bean meal in the manufacture of compound feeds in Great Britain. The LINK project (RD 2009-3638 - Environmental and Nutritional Benefits of Bioethanol Co-Products) (ENBBIO LINK) has investigated the inclusion of WDDG in diets for pigs, poultry and dairy cows. There is therefore a need to evaluate use of WDDG in diets for sheep.

The objective of the project reported here is to compare alternative protein sources to soya bean meal for pregnant ewes on a complete diet system based on grass silage.

The rations offered were based on grass silage with added protein and energy (fodder beet or cereals) to meet energy and protein needs in late pregnancy. Complete diets were formulated to provide similar amounts of energy and crude protein but with metabolisable protein levels varying according to protein source. The six treatments are listed below:

1. Control - Soya bean meal with cereals
2. Rapeseed meal with cereals
3. Wheat distillers dark grains (WDDG) with cereals
4. Field beans with cereals
5. Rapeseed meal with fodder beet
6. WDDG with fodder beet

Approximately 240 ewes aged 1-7 years, scanned as carrying twin lambs and due to lamb Feb/Mar 2014 were randomly allocated to six treatment groups of 39-40 ewes at housing in January 2014. Ewe live weight and body condition was assessed to weaning and lamb performance to sale or retention in October.

1.1 Key findings

1. Ewe live weight and body condition score were unaffected by the main protein source fed in late pregnancy at any stage between housing in January and weaning in July.
2. Performance of twin lambs offered creep feed was consistently above 300g/day between birth and eight weeks of age on all treatments.
3. Lamb birth weights, 4 week weights, 8 week weights and the associated daily liveweight gains did not differ between treatments.
4. The study demonstrated that rapeseed meal, wheat distillers grains and beans can all be used as substitutes for soya bean meal in the diets of twin bearing and rearing ewes in complete diets based on good quality grass silage. The ewes in this study were very fit at housing in January (mean body condition score 3.8) and the silage was of good quality (around 10.8 MJ/kgDM) which meant supplementary feed was only introduced 4 weeks pre-lambing and fed at a relatively low level (up to 0.45 kg/hd/day at lambing). On a poorer silage (10.0 – 10.3 MJ/kgDM) supplementary feed would be introduced sooner (from 6 weeks pre-lambing) increasing gradually to around 0.75 kg/head at lambing.
5. Total supplementary feed costs (excluding minerals) were highest for the Barley/soya group (£2.96/head). The cheapest diet was the Barley/WDDG diet (£2.57/head) thus achieving a saving of £0.39/head.
6. Estimated supplementary feed costs for ewes fed poorer silage were calculated to be approximately twice those calculated in this study resulting in a cost differential between the most expensive and cheapest rations of £0.80/head.

2 Introduction

Diets for pregnant ewes often include some soya bean meal to provide the high quality protein needed to meet digestible undegradable protein (DUP) requirements, and soya is often included in creep feeds for lambs and various other mixes. However almost all soya is imported into the UK from South America and there is a need to evaluate other protein sources that can be grown in the UK to improve the long term sustainability of UK sheep production. Anecdotally some major retailers have expressed concern over the use of soya in ruminant diets and would prefer to see the meat they purchase in the future to have been produced without the need for soya.

Soya contains high quality protein, has an excellent balance of amino acids and high energy levels (13.5 MJ/kg DM). It is an important ingredient in diets for pigs, poultry, dairy cows and breeding ewes. High demand, rapid price increases and the fact that soya is not grown in a sustainable environment have raised real concerns over its long-term availability and use. Producers and feed compounders are looking at home grown proteins (including forages) more closely to improve the long term sustainability of feed supplies for ruminants.

Typically the range of protein sources used in sheep diets includes: grass and forage crops, soya bean meal, rapeseed meal, palm kernel, field beans, sunflower seed meal, distillers dark grains and various other products e.g. wheatfeed, maize gluten, malt culms, lucerne, linseed meal etc. Currently about 3% of the soya used in the UK is used for sheep.

New research by the Royal Agricultural College (Baines and Jones, 2010) for Friends of the Earth shows that 50 per cent of soya meal currently used for animal feed in the UK could be directly replaced by home-grown alternatives. This would require 8 per cent of UK arable land.

It is critical that a high quality ration is offered to ewes in late pregnancy to maintain body condition, give optimal lamb birth weight and sufficient high quality colostrum. A good quality concentrate ration should have approximately 30% of the protein source as digestible undegradable protein (DUP) and this is often supplied by soya bean meal (SBM). Indeed soya is advised as a straight at 100g/lamb expected (Vipond, 2010) to boost colostrum quality and milk yield. The current AFRC recommendations (AFRC 1995) are widely used as the nutritional standards for sheep but questions have been raised, particularly about the level of metabolisable protein required by pregnant and lactating ewes (Robinson, 2008) and increases of up to 20% have been suggested above the AFRC guidelines for ewes in late pregnancy.

2.1 Alternatives to soya

The UK is self-sufficient in rapeseed meal (RSM) and since no GM oilseed rape is currently authorised to be grown in the EU, supplies are GM-free. It is a high-protein feed, typically containing approximately 34% protein, i.e. approximately 75% that of SBM, although the amino acid profile of RSM is higher than that of the majority of other vegetable proteins. Fed alone, RSM is unpalatable. However, it can be used as a cost-effective and practical alternative to SBM provided compensation is made for its naturally lower energy and protein levels. RSM has a number of anti-nutritional factors that potentially reduce the scope for use in livestock diets. These include glucosinolates, tannins and sinapine. Extensive plant breeding programmes have been undertaken to reduce levels of these in the seed and meal. Maximum levels of glucosinolates are established in the feedingstuffs legislation. Tannins, which are predominantly present in the seed coat, bind to soluble proteins rendering them unavailable for digestion.

Lupins have shown particular promise as a substitute for soya but extensive experimentation with lupins over the last 10 years has produced little in terms of yield or reliability.

Cereals and rolled dried beans are the basis of many home mix rations, particularly in the organic sector. Field beans and peas are good sources of starch and rumen degradable protein. Beans are less palatable than peas although crimping can allow greater inclusion rates by breaking down the anti-nutritional tannins in the bean. Although peas and beans contain tannins and trypsin inhibitors, these are relatively unimportant for ruminants. The supply of field beans could be increased if beans become economically viable compared to rapeseed. Currently about 115,000 ha are grown in the UK and this area could be extended if arable farmers see this is a viable alternative to rape. The relative value of beans compared to rapeseed meal (beans £222/tonne vs rapeseed meal at £233) is currently about break even.

Field peas are a very palatable feedstuff for all classes of cattle and sheep, and may best be used where nutrient density and palatability are important, such as in creep feeds. They can be used to replace SBM in rations for growing animals (heifers, beef cattle, lambs). However, due to the relatively fast rate of protein degradation in the rumen, a source of undegradable protein – as found in SBM – is required for high yielding dairy cows and pregnant ewes.

Energy and protein content of alternative protein sources (AFRC, 1995)

	Metabolisable energy MJ/kgDM	Crude Protein %	DUP % @5% outflow
Soyabean meal	13.3	50	14.6
Beans	13.1	30	3.9
Peas	13.5	25	3.2
Lupins	14.2	34	4.4
Wheat distillers dark grains	12.4	30	1.2*

*A wide range of figures is quoted across the industry and more recent estimates would suggest a much higher value than AFRC.

Work carried out by ADAS between 1999 and 2002 showed the effectiveness of distillery by-products (maize and barley) with and without beans when compared to rapeseed meal and soya bean meal as supplements to straw based diets for pregnant ewes. A 70:30 barley distillers and sugar beet mix can replace a whole barley/soya-bean ration when fed to twin-bearing ewes on straw diets without affecting ewe or lamb performance. However, substituting 20% of the diet with beans to replace barley/maize distillers, led to greater ewe weight loss during pregnancy and smaller lambs at birth, but no long term detrimental effects (Chapple et al 2000).

During 2009, Ensus opened a new bioethanol plant on Teeside, potentially processing 1 Mt of wheat per annum, and producing 0.3-0.35 Mt of wheat distillers dark grains (WDDG). This is the biggest bioethanol plant of its kind in Europe. In 2010, a second plant of similar size operated by Vivergo opened on Humberside. Together these two plants will account for *c.* 2 Mt of wheat per annum processed, and an output of at least 600,000 t WDDG for the animal feed market. WDDG has a relatively high protein content – typically 38-42% - and in crude protein terms this represents approximately 40% of the crude protein supplied by SBM in the manufacture of compound feeds in Great Britain. WDDG contains high levels of fibre, making it most suitable as a feed for ruminants. In cattle, there is some evidence that including WDDG may result in increasing levels of nitrogen (N) and phosphorus (P) excreted by cattle compared to conventional diets. If significant supplies of WDDG become available in the UK for use as livestock feed, protein sources used in compound feed formulations may change, and this will be reflected in changes in the total protein and amino acid profiles of rations.

The current LINK project (RD 2009-3638 - Environmental and Nutritional Benefits of Bioethanol Co-Products) (ENBBIO LINK) is looking at inclusion of WDDG in diets for pigs, poultry and dairy cows. There is therefore a need to evaluate use of WDDG in diets for sheep.

Urea is a source of rumen degradable protein and can be used to supplement low protein forages (e.g. maize and straw) however it is not an ideal supplement to grass silage based diets where rumen degradable protein is generally in good supply. Since urea is manufactured from petrochemicals it cannot be considered to be a sustainable protein source in the context of this project.

3 Objective

The objective of the project was to compare alternative protein sources to soya bean meal for pregnant ewes on a complete diet system based on grass silage.

4 Materials and methods

4.1 Site and Animals

The trial was undertaken at Reaseheath College in Cheshire. Approximately 240 ewes aged 1-7 years, scanned as carrying twin lambs and due to lamb from mid-February 2014 were randomly allocated to six treatment groups of 39-40 ewes at housing in January 2014. Ewes were predominantly North of England Mule or Texel x Mule mated with Texel or Charollais rams.

4.2 Treatments

Rations were based on chopped grass silage with added protein and energy (fodder beet or cereals) to meet energy and protein needs in late pregnancy. Complete diets (TMR) were formulated to provide similar amounts of energy and crude protein but with metabolisable protein levels varying according to protein source. The six treatments are listed below:

1. Control - Soya bean meal with cereals
2. Rapeseed meal with cereals
3. Wheat distillers dark grains (WDDG) with cereals
4. Field beans with cereals
5. Rapeseed meal with fodder beet
6. WDDG with fodder beet

4.3 Diet formulation

The base forage for all diets was big bale grass silage. Analytical results from a sample taken in October 2013 were used to guide the initial diet formulation. Standard values (as provided by GLW feeds) for analysis of the straights were used. Additional grass silage samples were taken in January and February 2014 (Table 1). Energy levels were reasonably consistent across the three samples ranging from 10.8 – 11.3 MJ/kgDM. Crude protein results were initially high (149-152 g/kg) but the February sample was significantly lower at 107 g/kg.

Table 1 Grass silage analyses

		October 2013	January 2014	February 2014
Dry matter*	g/kg	630	596	537
D Value	%	67.4	70.7	68
ME	MJ/kg	10.8	11.3	10.9
FME	MJ/kg			9.3
NDF	g/kg	487	486	559
Ash	g/kg	74	78	78
Oil - A	g/kg			20
pH*		4.9	6.0	4.5
Ammonia N	% of total N	1.2	3.2	3.3
Crude Protein	g/kg	149	152	107

- results reported on a dry matter basis except where marked *

The complete diet formulations and estimated energy and protein supplied by each are shown below in Table 2. Ewes started on the 4 week ration on 27th January. Energy and crude protein levels were formulated to be similar for all treatments but predicted DUP levels differed according to the protein source. The barley/soya ration had the highest DUP (47g/day at lambing), followed by the rape diets, with the lowest levels achieved in the WDDG rations at 27 g/day at lambing.

Table 2 Diet composition pre-lambing (kg/hd/day as fed) and estimated energy and protein supplied

Treatment		Weeks pre-lambing			
		6	4	2	1
Barley/soya	Silage	2.5	2.5	2.2	2.2
	Barley		0.1	0.25	0.325
	Soya bean meal		0.05	0.10	0.125
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.1*	*18.8*	*19.7*
	Crude protein (%)		*14.3*	*15.4*	*15.9*
	ERDP (g/day)		*138*	*159*	*170*
	DUP (g/day)		*31*	*41*	*47*
Barley/rape	Silage	2.5	2.5	2.2	2.2
	Barley		0.10	0.20	0.25
	Rapeseed meal		0.07	0.15	0.20
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.3*	*18.9*	*19.8*
	Crude protein (%)		*13.9*	*15.0*	*15.6*
	ERDP (g/day)		*139*	*161*	*175*
	DUP (g/day)		*29*	*37*	*41*

Treatment		Weeks pre-lambing			
		6	**4**	**2**	**1**
Barley/WDDG	Silage	2.5	2.5	2.2	2.2
	Barley		0.05	0.18	0.23
	WDDG		0.10	0.17	0.22
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.1*	*18.7*	*19.5*
	Crude protein (%)		*14.1*	*14.9*	*15.5*
	ERDP (g/day)		*140*	*160*	*173*
	DUP (g/day)		*24*	*26*	*27*
Barley/beans	Silage	2.5	2.5	2.3	2.3
	Barley		0	0.10	0.10
	Beans		0.15	0.20	0.30
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.5*	*18.9*	*20.0*
	Crude protein (%)		*14.0*	*14.3*	*15.0*
	ERDP (g/day)		*141*	*153*	*169*
	DUP (g/day)		*28*	*32*	*36*
F Beet/rape	Silage	2.5	2.5	2.2	2.2
	Fodder beet		0.50	0.70	1.0
	Rapeseed meal		0.07	0.18	0.22
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.1*	*18.6*	*19.4*
	Crude protein (%)		*13.5*	*14.9*	*15.2*
	ERDP (g/day)		*134*	*158*	*167*
	DUP (g/day)		*28*	*37*	*41*
F Beet/WDDG	Silage	2.5	2.5	2.2	2.2
	Fodder beet		0.50	0.60	0.80
	WDDG		0.10	0.22	0.28
	Mineral		0.03	0.03	0.03
Ration supplies	*ME (MJ/day)*		*17.3*	*18.5*	*19.3*
	Crude protein (%)		*13.7*	*15.1*	*15.6*
	ERDP (g/day)		*138*	*162*	*174*
	DUP (g/day)		*23*	*25*	*25*

- Rations formulated based on 85kg mule ewes CS 3.5 at 6 weeks pre-lambing

Ewes stayed on their original treatment rations until the number left to lamb in a group fell below 15. At this point ewes in these groups were offered a universal ration (2.5kg silage, 0.3 kg barley, 0.1 kg soya and 0.1kg WDDG) to simplify feeding.

4.4 Management

Twin-bearing ewes were weighed and their body condition assessed at housing on 13 January. Sheep were housed in six groups of 39-40 ewes, four groups in a portal framed building and two in a plastic-covered polytunnel. At housing ewes were offered grass silage only and intakes and refusals were monitored to assess ewe appetite and inform the final ration formulation. Ewes were in very good body condition (average 3.8 condition score, see Table 7) in January on allocation to treatment and supplementary feed was only introduced from four weeks pre-lambing. Rations were formulated to fully satisfy ewes' appetite and were fed from a complete diet feeder every other day (Monday, Wednesday and Friday) with refusals recorded.

Blood samples were taken from four ewes per group by the farm vet on 6 February 2014 and analysed for β-hydroxybutyrate, urea and albumin to check the adequacy of the diets for energy and protein (Table 6).

Lambing started on 20 February 2014 with an average lambing date of 10 March. At lambing ewes were weighed and condition scored and their lambs weighed and tagged shortly after birth. Male lambs were castrated at tagging. After a period indoors ewes and their lambs were turned out to ryegrass swards where lambs had access to creep feed. Creep feeding continued until weaning in July.

Ewe live weights and condition scores and lamb weights were collected when lambs were approximately four and eight weeks of age and at weaning (Tables 7-10). Lambs were sold post-weaning, when finished, direct to an abattoir with a total of three batches sold between weaning and early October. Individual live weights on leaving the farm, cold carcass weights and carcass gradings were collected for all trial lambs (Table 11). A final weight in October 2014 was taken of ewe lambs retained for breeding and lambs that remained to be sold finished.

5 Results and discussion

5.1 Feed analysis

Samples of complete diets were taken twice in the pre-lambing period, 11 February and 10 March 2014. Diets were sent for analysis to Sciantec and the results are shown below in Tables 3 and 4. Crude protein content of the complete diets was predicted (from Table 2) to be in the range 14.3 – 15.4 % at approximately two weeks pre-lambing and was reasonably close to the crude protein reported by analysis in February (Table 3). However, despite the compound component of all the diets increasing closer to lambing the analysis of the March diets (Table 4) showed lower protein levels than expected. Crude protein content of the complete diets was predicted to be in the range 15.0 – 15.9 % at one week pre-lambing but the reported analysis was much lower at 8.8 – 10.7 %.

Table 3 Complete diet analysis – 1st sample - 11 February 2014

		Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG
Dry matter *	g/kg	537	474	446	453	439	439
Crude protein	g/kg	143	141	143	146	139	139
Neutral detergent fibre	g/kg	510	508	531	510	542	513
Ash	g/kg	86	84	81	88	84	87
Total oil (Oil B)	g/kg	33	33	32	30	31	33
NCGD	g/kg	657	632	630	658	608	644
Calcium	%	0.6	0.7	0.6	0.8	0.6	0.6
Phosphorus	%	0.4	0.4	0.4	0.4	0.3	0.4

* Results are reported on a dry matter basis except where marked

Table 4 Complete diet analysis – 2nd sample - March 2014

		Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG	Composite diet
Dry matter *	g/kg	346	Not sampled ewes on composite diet		314	321	336	320
Crude protein	g/kg	89			88	98	107	78
Neutral detergent fibre	g/kg	359			415	435	431	359
Ash	g/kg	63			68	84	73	54
Total oil (Oil B)	g/kg	20			19	21	24	19
NCGD	g/kg	579			560	534	601	558
Calcium	%	0.5			0.4	0.6	0.5	0.3
Phosphorus	%	0.3			0.3	0.3	0.3	0.2

* Results are reported on a dry matter basis except where marked

5.2 Diet costs

Supplementary feed costs (Table 5) were calculated based on the quantities fed throughout the pre-lambing period (assuming ewes were fed the 1 week pre-lambing ration for three weeks on average) and the spot prices for the straights in January 2014 and an assumed fodder beet price of £30/tonne. Mineral and vitamin costs were the same for all treatments and have been excluded from the calculations below.

	£/t	P/kg
Barley	140	14.0
Fodder beet	30	3.0
Soya bean meal	388	38.8
Rapeseed meal	238	23.8
Wheat distillers dark grains	224	22.4
Beans	232	23.2

Table 5 Supplementary feed cost (excluding minerals) from 4 weeks pre-lambing to mean lambing date (£/hd)

	Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG
Barley	1.40	1.13	0.95	0.39	0	0
Fodder beet	0	0	0	0	0.99	0.84
Soya bean meal	1.59	0	0	0	0	0
Rapeseed meal	0	1.48	0	0	1.63	0
WDDG	0	0	1.62	0	0	1.98
Beans	0	0	0	2.27	0	0
Total supplement (£/head)	£2.96	£2.61	£2.57	£2.66	£2.62	£2.82
Total supplement fed (kg/head) (fresh wt)	14.0	14.3	14.0	12.6	39.8	36.8

Feed costs were highest for the barley/soya group and lowest for barley/WDDG resulting in maximum savings of £0.39/ewe. The total amount of feed offered was modest in this study as ewes were very fit when housed and good quality grass silage was fed. Had a poorer quality silage been offered supplementation would have started earlier and the amount fed increased. If supplementation is assumed to start at 0.2 kg six weeks pre-lambing increasing gradually to 0.75 kg at one week pre-lambing the total amount of feed offered to the control group would increase to 28.4 kg at a cost of £6.05 (approximately twice that offered in this study). Using the same assumptions for the barley/WDDG results in feed costs of approximately £5.25, a saving of £0.80/ewe.

5.3 Metabolic blood tests

Blood samples were taken from four ewes per group in early February 2014 and the mean results are shown in Table 6 below. Unfortunately three of the test results could not be reliably allocated to their treatment groups and these results have been excluded from the table. In general the blood results were unremarkable, with the vast majority falling within the normal reference ranges. However, one of the ewes on fodder beet and WDDG had raised β-hydroxybutyrate – lifting the overall mean for this group. As a result of this the decision was taken to bring forward the 1 week pre-lambing ration by approximately 3-4 days to reduce the chance of problems close to lambing. Pregnancy toxaemia was noted in a couple of ewes around lambing but was not considered to be a significant issue.

Table 6 Results of metabolic blood tests pre-lambing (6 February 2014)

	Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG
BHB (mmol/l) Ref range (<1.2)	0.54	0.40	0.41	0.50	0.40	0.98
Albumin (g/l) Ref range (24-34)	31.2	31.0	33.9	32.2	32.0	30.8
Urea (mmol/l) Ref range (2.6-6.6)	4.3	4.8	4.3	4.7	4.5	4.9

Blood samples from 3 - 4 ewes / group

5.4 Animal performance

Ewe live weight and body condition score data for all ewes allocated to the trial are presented in Table 7. At housing in January ewes were in very good condition, weighing 89 kg and with a body condition score of 3.8. Live weight and body condition score were similar for all treatments.

Table 7 Mean live weights and body condition scores for all ewes allocated at housing

	Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG	*signif*
Housing – all ewes allocated							
No. ewes allocated	39	40	39	39	39	39	
Weight (kg)	90.2	89.7	88.3	90.3	87.4	92.1	*NS*
Condition score	3.7	3.8	3.8	3.7	3.7	3.8	*NS*

Although all trial animals had been pregnancy scanned as carrying twins a significant number of ewes delivered single or triplet lambs and some ewes were found to be empty at the end of lambing. For the purposes of analysing ewe performance the dataset has been restricted to twin bearing and twin rearing ewes and this is reported in Table 8.

Restricting the analysis to twin bearing ewes did not affect the overall mean live weight or condition score at housing (Table 8). Ewes averaged 89 kg and body condition score of 3.8 as above and were similar across all treatments. Ewe live weight and body condition scores remained similar for all treatments on each of the subsequent assessment dates between lambing and weaning. Between housing and immediately post-lambing ewes typically lost an average 0.6-0.8 of a condition score and 7-10kg (average 81 kg and condition score 3.1 at lambing). Ewes lost a further 0.5 of a condition score in early lactation to average 2.6 at 4 weeks post-lambing. By 8 weeks post-lambing ewes on all treatments were gaining weight and body condition and by weaning had improved to an average condition score of 3.1.

Table 8 Mean live weights and body condition scores for twin-bearing/rearing ewes

	Barley soya	*Barley rape*	*Barley WDDG*	*Barley bean*	*F Beet rape*	*F Beet WDDG*	*Signif.*
Housing – 13 January							
No. ewes (twins)	24	27	27	21	19	18	
Weight (kg)	88.5	90.4	86.6	90.6	87.3	90.0	*NS*
Condition score	3.7	3.8	3.8	3.8	3.7	3.8	*NS*
Lambing							
Weight (kg)	81.1	83.4	80.1	79.7	77.1	81.5	*NS*
Condition score	3.0	3.0	3.2	3.2	3.1	3.1	*NS*
4 wk assessment							
Weight (kg)	80.8	82.3	81.8	82.2	77.7	81.9	*NS*
Condition score	2.5	2.5	2.8	2.7	2.6	2.7	*NS*
8 wk assessment							
Weight (kg)	83.1	84.9	83.7	84.4	81.1	83.1	*NS*
Condition score	2.7	2.6	3.0	2.9	2.8	2.8	*NS*
Weaning							
Weight (kg)	74.6	71.5	72.9	73.2	73.3	74.3	*NS*
Condition score	3.0	2.9	3.3	2.9	3.1	3.3	*NS*

For the purposes of reporting lamb performance to eight weeks of age, when diets are most likely to have an influence, only lambs born and reared as twins have been included in the following table. Very late born lambs have also been excluded as have lambs that did not have complete data for all of the key weigh dates (birth, 4 weeks and 8 weeks). The analysis has therefore been carried out on a core group of lambs that have complete datasets to 8 weeks of age. Table 9 reports lamb weights and daily liveweight gains from birth to four and eight weeks of age for this core group. To allow for differences in age at assessment the four and eight week weights have been adjusted to 28 and 56 days.

Table 9 **Performance of twin born and reared lambs (restricted to lambs with complete data at birth, 4 wks and 8 wks)**

	Barley soya	**Barley rape**	**Barley WDDG**	**Barley bean**	**F Beet rape**	**F Beet WDDG**	***Signif***
Birth data							
Mean birth date	11 Mar	6 Mar	7 Mar	11 Mar	10 Mar	9 Mar	
Birth weight (kg)	4.43	4.62	4.30	4.24	4.57	4.24	*NS*
4 week data							
28 day weight (adjusted) (kg)	13.9	14.3	13.4	14.0	13.1	13.5	*NS*
DLWG to 4 wks (g)	339	345	324	348	306	331	*NS*
8 week data							
56 day weight (adjusted) (kg)	23.6	23.9	23.0	23.8	23.1	22.4	*NS*
DLWG to 8 wks (g)	342	344	334	349	331	325	*NS*
DLWG 4-8 wks (g)	333	341	343	341	339	318	*NS*

Lambs in the core group averaged 4.42 kg at birth and weights did not differ significantly between treatments (P>0.05). Daily growth rates to four weeks of age averaged over 300 g for all treatments with an average weight at 28 days of 13.8 kg. Overall, significant differences were not observed between treatments although the fodder beet/rape group tended to have lower growth rates than the barley/rape and barley/bean groups (306 g/day vs. 345 and 348 g/day respectively). Lambs continued to grow at over 300 g between 4 and 8 weeks of age for all treatments with a mean weight of 23.4 kg at eight weeks of age.

To compare performance of lambs from eight weeks of age to weaning and then to sale (or retention) the dataset was expanded to include all twin born and reared lambs (Table 10). Overall, significant differences were not observed between treatments either to weaning or to the end of the study (P >0.05). Growth rates to weaning averaged 254 g/day. The overall weight of lamb reared to sale or retention was calculated from the final lamb weights and ranged from 85.8 kg for ewes rearing twins on the F beet/rape diets to 90.6 kg for ewes on the Barley/beans diet. These final figures may have been slightly influenced by the number of ewe lambs retained for breeding in each group but overall the weight of lamb reared was similar for each treatment.

Table 10 Performance of twin born/reared lambs to end of study (includes all twin born and reared lambs)

	Barley soya	**Barley rape**	**Barley WDDG**	**Barley bean**	**F Beet rape**	**F Beet WDDG**	***Signif.***
Birth data							
Birth weight (kg)	4.49	4.57	4.31	4.28	4.45	4.26	*NS*
8 week data							
56 day adjusted wt (kg)	23.2	23.8	22.9	23.3	22.0	21.4	*NS*
DLWG to 8 wks (g)	336	340	331	344	313	308	*NS*
Weaning data							
Age at weighing (days)	122	127	128	124	123	124	*NS*
Weight (kg)	34.1	36.8	36.2	36.9	34.6	36.7	*NS*
DLWG to weaning (g)	243	254	250	265	247	263	*NS*
Final weight (sale/October)							
Age at final weighing (days)	193	188	189	191	192	188	*NS*
Weight (kg)	43.2	44.6	44.1	45.3	42.9	44.8	*NS*
Overall weight of lambs reared (twin rearing ewe) (kg) *	86.4	89.2	88.2	90.6	85.8	89.6	

* Overall weight of lamb reared by each treatment may be affected by the number of ewe lambs retained for breeding in each group.

5.5 Lamb sale information

A total of three batches of lambs were sold between weaning in July and the trial end date in October. The final on-farm weight, cold carcass weight (CCW), killing out percentage and carcass grades are shown below in Table 11. Significant differences between treatments were seen for killing out percentage (P=0.03) with the barley/soya, barley/bean and fodder beet/WDDG groups killing out better than the barley/rape and fodder beet/rape groups. However these results need to be treated with caution as they are based on a relatively small number of lambs and kill dates and may not be representative of the study as a whole. The final live weight, cold carcass weight and carcass grades were similar for all treatments.

Table 11 Lamb sale and carcass information (first three batches)

	Barley soya	Barley rape	Barley WDDG	Barley bean	F Beet rape	F Beet WDDG	*Signif*
On-farm data							
No. lambs sold	18	28	23	18	17	18	
Mean date	18 Aug	18 Aug	9 Aug	22 Aug	28 Aug	19 Aug	
Final weight (kg)	42.1	43.4	43.3	43.3	42.3	42.9	*NS*
Abattoir data							
CCW (kg)	18.4	18.1	18.4	18.9	17.6	18.4	*NS*
Kill out %	43.9[a]	42.0[cd]	42.7[bc]	43.9[a]	41.5[d]	43.0[ab]	*P=0.03*
Conformation							
No. lamb records	18	25	23	18	16	18	
E	0	0	1	0	0	0	*NS*
U	5	4	4	5	2	2	
R	11	18	18	12	11	16	
O	2	3	0	1	3	0	
Fat class							
No. lamb records							
1	2	0	0	0	0	0	
2	7	11	10	6	9	7	*NS*
3L	9	14	13	12	7	10	
3H	0	0	0	0	0	1	

6 Conclusions

1. Ewe live weight and body condition score were unaffected by the main protein source fed in late pregnancy at any stage between housing in January and weaning in July.
2. Performance of twin lambs on creep feed was consistently above 300g/day between birth and eight weeks of age on all treatments.
3. Lamb birth weights, 4 week weights, 8 week weights and the associated daily liveweight gains did not differ between treatments.
4. The study demonstrated that rapeseed meal, wheat distillers grains and beans can all be used as substitutes for soya bean meal in the diets of twin bearing and rearing ewes on complete diets based on good quality grass silage.
5. The ewes in this study were very fit at housing in January and the silage was of good quality (around 10.8 M/kgDM) which meant supplementary feed was only introduced 4 weeks pre-lambing and fed at relatively low level (up to 0.45 kg/hd/day at lambing). On a poorer silage (10.0 – 10.3 MJ/kgDM) supplementary feed would be introduced sooner (from 6 weeks pre-lambing) increasing gradually to around 0.75 kg/head at lambing.
6. Total supplementary feed costs (excluding minerals) were highest for the barley/soya group (£2.96/head). The cheapest diet was the barley/WDDG diet (£2.57/head) that achieved a saving of £0.39/head.
7. Estimated supplementary feed costs for ewes fed poorer silage were calculated to be approximately twice those calculated in this study resulting in a cost differential between the most expensive and cheapest rations of £0.80/head.

7 References

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