The effects of incorporating either lupins or soya bean meal into concentrate diets when compared with a control concentrate diet on the performance and carcase characteristics of finishing lambs

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Introduction Soya bean (*Glycine max*) meal is an important component of animal feed and oil seed rape and palm kernel cake and meal are typically used in commercial concentrate diets for sheep in the UK.. Lupins (*Lupinus; Leguminosae*) as a high protein, high energy, nitrogen-fixing grain legume, have potential as a home-grown livestock feed in the UK (Wilkins and Jones, 2000). Research has been conducted on the effects of narrow-leafed lupins (*Lupinus angustifolius*) (Hill, 2005) but there have been few studies on the effects of yellow lupins (*Lupinus luteus*) when fed to sheep. This study investigated the effects of incorporating either yellow lupins, narrow-leaf lupins or soya bean meal into the concentrate diets of finishing lambs on lamb productivity and carcass characteristics when compared to a commercial UK lamb finisher diet.

Materials and methods The experiment comprised of a lamb finishing experiment, using eighty male castrated Suffolk-cross lambs to give with 20 lambs on each of 4 dietary treatments. Treatments were narrow-leafed lupin (cv. Prima), yellow lupin (cv. Wodjil), soya bean meal and a commercial (control) lamb finisher diet. The concentrate diets (pelleted) had a target nitrogen concentration of 25.7 g/kg DM (16 % CP) and ME of 11.0 MJ/kg DM. The two lupin varieties for the experiment were produced on the same experimental site (at IBERS) and harvested according to standard practice. The experiment consisted of 3 phases: a 14-d covariate, a 14-d adaptation and an 8-week measurement period (Day 0 - 56). During the covariate period, lambs were kept as one group on a ryegrass /clover sward. At the start of the adaptation period, lambs were allocated to their replicate blocking group within each treatment on the basis of live weight and body condition score. Prior to the measurement period, lambs were housed and dietary treatments were gradually introduced, along with straw as the fibre component of the diet. Each blocking group was allocated at random to a set of adjacent pens (n = 5 per pen) and treatments allocated at random to pens within this. During the measurement period, animals were offered straw and supplemental concentrate *ad libitum*, with a refusal margin of 0.10 to 0.15 d^{-1}. Concentrate as offered was DM sampled and sub-sampled daily and bulked weekly, freeze dried and ground for chemical analysis. Individual lambs were weighed and condition scored every 7-d throughout the experiment. The measurement period was divided into two phases. During week 1 to 4, liveweight gain data from all lambs were recorded. From week 5 onwards, lambs were selected-out for slaughter as they reach a target fat class of 3L and live weight and cold carcass weight were used to determine killing-out percentages. Daily liveweight gain data were compared using a non-parametric regression of Theil (1950), as implemented by Dhanoa (1998).

Results The DM content of the concentrate diets were 859, 850, 867 and 874 g kg^{-1} freshweight for the soya bean meal, narrow leaf lupin, yellow lupin and control diet, respectively. The N concentration of the soya bean meal, narrow-leaf lupin, yellow lupin and control diet was 32.2, 32.9, 33.4 and 30.8 g kg^{-1} DM, respectively. The ME concentration of the soya bean meal, narrow-leaf lupin, yellow lupin and control diet was 12.5, 12.8, 12.6 and 12.6 MJ/kg DM, respectively. There was no significant effect ($P > 0.05$) of dietary treatment on the liveweight gain of lambs offered the different diets. The liveweight gain of lambs offered concentrates incorporating soya, narrow-leaf lupin, yellow lupin or a commercial control diet were 185, 229, 193 and 166 g/d, respectively (s.e.d. 34.6) The carcase characteristics of the lambs are given in Table 1.

Table 1 Carcass characteristics (mean ± se) and number of days to finish of lambs offered concentrates containing either soya bean meal, narrow-leaf lupins, yellow lupins or commercial control finisher diet *ad libitum*.

	Soya	Narrow-leaf lupin	Yellow lupin	Control
Empty liveweight (kg)	38.5 ± 0.77	38.3 ± 0.52	38.5 ± 0.70	37.6 ± 0.61
Hot carcass weight (kg)	19.3 ± 0.39	19.4 ± 0.32	19.8 ± 0.40	18.8 ± 0.35
Killing-out %	50.1± 0.34	50.7 ± 0.37	51.3 ± 0.31	50.1 ± 0.32
Days to finish	33 ± 2.1	30 ± 0.5	32 ± 2.0	32 ± 1.8

Conclusion Overall, the findings from this study show that both narrow-leaf and yellow lupins could be used as a home-grown alternative to imported soya or a bought-in commercial concentrate, containing rapeseed meal and palm kernel, for finishing lambs in the UK without any adverse effects on lamb productivity or carcass killing-out percentages.

Acknowledgements This work was sponsored by Defra through the Sustainable Arable LINK Programme in association with the University of Newcastle, The Arable Group (TAG), Processors and Growers Research Organisation (PGRO), Associated British Agriculture Ltd (AB Agri.), Germinal Holdings Ltd., Kelvin Cave Ltd., DairyCo and MLC.

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Effects of replacing grass silage with maize silage or concentrates on lamb output from housed pregnant ewes

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Introduction Rations for pregnant ewes in the UK are often based on grass silage. However, due to a number of factors, the cost of producing high quality grass silage has increased significantly in recent years so lower cost alternatives need to be investigated. Production of forage maize has the potential to reduce forage costs on mixed beef/sheep farms, with high dry-matter yields (comparable to that of a 3-cut silage system) of high quality maize silage possible from a single harvesting operation (Easson and Fearnehough, 2000). However there is limited information on the effects of feeding maize silage to pregnant ewes. Alternatively, grass silage could be eliminated from rations by feeding high grain diets. The aims of this study were to evaluate the effects of replacing grass silage with either maize silage or concentrates on the performance of housed pregnant ewes and their lambs.

Materials and methods Seven weeks prior to lambing, 104 twin-bearing ewes (80±10.2 kg live weight, condition score 3.8±0.21) were housed, shorn and allocated to one of four treatments, balanced for live weight, body condition and crossing sire breed. For the final 6 weeks of pregnancy, ewes were offered one of four diets: precision chop grass silage + 0.55 kg/d concentrate (GS, Treatment 1); maize silage + 0.55 kg/d concentrate (MS, Treatment 2); a mixture (1:1 on a dry-matter basis) of grass silage and maize silage + 0.55 kg/d (GS/MS, Treatment 3); or 1.55 kg/d concentrates + 50 g/d chopped barley straw (C, Treatment 4). All silages were offered on an *ad libitum* basis. The grass silage was predicted by Near Infrared Reflectance Spectroscopy to supply 278 g DM/kg, 670 g/kg digestible organic matter/kg DM, 10.7 MJ ME/kg DM and 121 g crude-protein/kg DM. Maize silage was predicted to supply 337 g DM/kg, 11.0 MJ ME/kg DM, 84 g CP/kg DM and 243 g starch/kg DM. Concentrates were formulated to supply 209, 293, 242 and 158 g CP/kg DM for Treatments 1-4 respectively, with the aim of achieving a total intake of 130 g metabolisable protein/ewe/day. Half of the ewes were housed individually and intakes were recorded daily for each animal. The remainder were housed in groups of 4-5, with intakes recorded daily for the entire group. Ewe live weight and condition score were measured 6, 4 and 2 weeks pre-lambing and within 24 h of lambing. Lambs were weighed at birth, 6 weeks of age and weaning. Daily live weight gain was determined by linear regression. Lambing difficulty was scored on a four-point scale where 1 = no assistance and 4 = manual delivery with difficulties. Data were analysed using Analysis of Variance (ANOVA) with diet as a fixed effect and covariates included for crossing sire breed, lamb sex and age at weaning, where appropriate.

Results Ewes offered maize silage as 0.5 or 1.0 total forage had higher intakes of silage DM (P<0.01) and total DM (P<0.001) during the final 6 weeks of pregnancy compared with ewes offered grass silage as the sole forage. Ewes offered the complete concentrate diet had the lowest DM intake. However there was no evidence of any dietary effects on the nutritional status of ewes, in terms of changes in live weight or condition score. Diet in late pregnancy had no significant effects on lamb output at birth or at weaning. However there was a higher incidence of lambing difficulties with MS compared with GS or C ewes, as shown by their higher mean lambing difficulty score. There were no residual effects of late pregnancy diet on lamb performance.

Table 1 Effects of replacing grass silage with maize silage or concentrates on ewe and lamb performance

	Grass Silage	Grass Silage + Maize Silage	Maize Silage	Concentrates + Straw	s.e.d	Sig
Forage dry-matter intake (kg/d)	1.03^{a}	1.18^{b}	1.15^{b}	-	0.046	**
Total dry-matter intake (kg/d)	1.50^{b}	1.64^{c}	1.62^{c}	1.21^{a}	0.041	***
Pre-lambing live weight change (kg)	-6.1	-4.2	-5.4	-7.4	1.36	NS
Pre-lambing condition score change	-0.46	-0.52	-0.50	-0.44	0.155	NS
Mean lamb birth wt (kg)	5.38	5.40	5.22	5.41	0.223	NS
Lambing difficulty score	1.46^{a}	1.53^{ab}	1.93^{b}	1.10^{a}	0.229	**
Lambs weaned/ewe	1.62	1.84	1.60	1.77	0.149	NS
Total weaning wt (kg)	57.8	64.1	55.1	60.4	4.87	NS
Daily live weight gain (g/d)	244	257	245	250	8.0	NS

Conclusion The results of this study demonstrate that maize silage can replace grass silage in pregnant ewe diets with no adverse effects on lamb output. However the higher intake characteristic of maize silage, without a concomitant increase in lamb output, suggests that feed conversion efficiency is lower than for grass silage. Also the higher incidence of lambing difficulties in ewes offered maize silage is a major concern and requires further investigation. Zero silage systems based on high concentrate inputs can also replace grass silage-based diets without affecting lamb output, although the economics of this system is dependent on concentrate feed costs.

Acknowledgement Funding from the Department of Agriculture and Rural Development (DARDNI) is gratefully acknowledged.

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Performance of crossbred Welsh Mountain ewes in the hill environment

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Introduction The Welsh Mountain sheep is a numerically important breed in the UK, but its lambs are characterised by low slaughter weights and poor carcass conformation. The reduction in stocking rates that is often associated with environmental conservation schemes, offers the potential for the use of larger ewes. Crossbreeding allows more rapid genetic change to be undertaken than would be possible from selection within breeds, and affords the potential to utilise heterosis and improve the quality of subsequent crosses with the Bluefaced Leicester. This work compared the survival and productivity of purebred Welsh Mountain ewes with a range of crossbred ewe types maintained in a hill environment.

Materials and methods Over a three year period, 600 Welsh Mountain ewes per year were mated to either Cheviot, Poll Dorset, Lleyn or Texel sires (8 high index sires per breed overall) using laparoscopic AI (McLean *et al*, 2006). Up to fifty ewe lambs per year were retained from each breed and a similar number of pure bred Welsh Mountain lambs were also retained each year from the farm flock. These pure Welsh Mountain and crossbred ewes were mated by Suffolk rams and ewe performance was recorded over 3 parities. Ewes were weighed and condition scored on a scale of 1 (thin) to 5 (fat) at the start of the mating period. All ewes in their first parity (two years old) were housed for the final 6 weeks of pregnancy and fed grass silage and concentrates according to predicted litter size. In subsequent parities only twin and triplet bearing ewes were housed, and single bearing ewes were maintained on pastures and fed grass silage supplemented with feed blocks until lambing. After lambing, single bearing ewes were grazed on semi-natural hill pastures at 1.5 ewes per ha, whilst twin rearing ewes were retained on improved perennial ryegrass based swards at up to 10 ewes per ha until lambs were weaned at 18 weeks of age. The data were analysed using the REML procedure of Genstat. For ewe performance traits, the fixed effects of breed, year, ewe age and their interactions were evaluated. Lamb performance traits were adjusted for the fixed effects of breed of dam, year, sex, litter size, ewe age and significant interactions, with age of lamb at the 8 week weighing and/or weaning fitted as covariates where relevant. Dam was fitted as a random effect.

Results There were no significant differences ($P>0.05$) between ewe types in pregnancy rates and survival to third lambing. Cheviot, Dorset and Texel crossbred ewes were approximately 8 kg (proportionately 0.2) heavier than the Welsh Mountain ($P<0.001$) and Lleyn cross ewes were intermediate in weight. Relative to the number of ewes that entered the flock, total litter weight weaned over three lamb crops was between 18.7 - 31.3 kg higher in crossbred ewe types than in the Welsh Mountain ($P<0.001$), although the relative contribution to this of litter size and individual lamb weaning weights varied between crossbreeds. The progeny of crossbred ewes were heavier at birth and weaning than lambs from Welsh Mountain ewes. However, although crossbred ewes supported higher growth rates in early lactation, there were no significant differences in ADG from 8 weeks to weaning ($P>0.05$).

Table 1 Performance of purebred Welsh Mountain and crossbred ewes and their Suffolk cross lambs

	Cheviot x	Dorset x	Lleyn x	Texel x	Welsh	s.e.d.	Significance
Number of ewes	135	136	145	130	126		
Ewe survival to 3rd lambing	0.72	0.64	0.74	0.62	0.61	0.056	n.s.
Ewe live weight at 3rd mating	50.3	50.9	46.9^{b}	51.2	42.5^{a}	0.86	P<0.001
Litter weight weaned† (kg)	97.1^{a}	103.3^{bc}	109.7^{c}	100.5^{b}	78.4^{a}	4.59	P<0.001
Pregnancy rate	0.85	0.86	0.86	0.85	0.81	0.030	n.s.
No lambs born/ewe lambing	1.49^{bc}	1.57^{cd}	1.63^{d}	1.43^{b}	1.33^{a}	0.049	P<0.001
No lambs reared/ewe lambing	1.42^{bc}	1.50^{cd}	1.52^{d}	1.37^{ab}	1.29^{a}	0.047	P<0.001
Lamb birth weight (kg)	3.8^{bc}	3.9^{cd}	3.7^{b}	4.0^{d}	3.3^{a}	0.07	P<0.001
Lamb weaning weight (kg)	29.4^{b}	30.4^{c}	29.2^{b}	30.7^{c}	27.0^{a}	0.36	P<0.001
ADG birth – 8 weeks (kg/day)	0.26^{b}	0.27^{c}	0.26^{b}	0.26^{bc}	0.24^{a}	0.006	P<0.001
ADG 8 weeks – weaning (kg/day)	0.14	0.15	0.15	0.15	0.13	0.005	n.s.

[a, b, c] Means within a row with different superscripts were significantly different ($P<0.05$)
† Total litter weight produced over three parities per ewe that entered the flock

Conclusions These results are similar to those of Speijers *et al* (2007) for crossbred Scottish Blackface sheep and demonstrate that, where stocking rates are adequate, larger, more productive crossbred ewes can be maintained in the hill environment without deleterious consequences for survival or pregnancy rate.

Acknowledgement Funding for this work was received from Hybu Cig Cymru – Meat Promotion Wales

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Effects of plane of nutrition and selenium supplementation of ewes in early and mid-pregnancy on meat quality of offspring

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Introduction Nutritional status in early and mid-pregnancy can affect subsequent offspring productivity. For example, plane of nutrition in early and mid-pregnancy has been shown to have a significant effect on carcass characteristics, with male offspring of dams offered a low plane diet in early pregnancy having poorer carcass conformation and greater fat depths over the muscle *L. dorsi* than lambs of dams offered medium or high plane diets (Muñoz *et al.* 2008a). Supplementation with selenium (Se) during this period had positive effects on measures of lamb viability and survival (Muñoz *et al.* 2008b). The aim of the current study was to investigate the effect of plane of nutrition and selenium supplementation of ewes in early and mid-pregnancy on the meat quality of the male offspring.

Materials and methods Between days 0 and 39 after synchronized mating (early pregnancy, EP) multiparous ewes (n = 99) were allowed 60% (low, L), 100% (medium, M) or 200% (high, H) of requirements for maintenance. Between days 40 and 90 (mid-pregnancy, MP), ewes were allowed either 80% (M) or 140% (H) of their maintenance requirement. Between days -14 and 90 post mating, ewes received Se treatments providing either no Se (Control) or 1 g of Selplex® = intake of 0.5 mg Se/ewe/day (Treated). After day 90 of gestation, all ewes were fed to meet energy and protein requirements for late pregnancy and supplemented with a standard multivitamin and mineral mix (Se content of 10 mg/kg). Male offspring (n = 73) were reared on a grass-based system and slaughtered at 42, 46 or 50 kg live weight (LW). Between ribs 6 and 12 the muscle *L. dorsi* was removed 24 h post-mortem for instrumental meat quality analyses. Measurements of pH, colour, cooking loss, Warner-Bratzler shear force (WBSF) and sarcomere length were recorded using the methods detailed by Moss *et al.* (1993). The data were analysed using the Genstat REML procedure in a 3 (EP plane of nutrition) X 2 (MP plane of nutrition) X 2 (Se supplementation) factorial design. The model examined the effects of the treatments, while adjusting for the effect of dam and sire breed, siblings and fat classification.

Results There were no statistically significant interactions between nutritional treatments, therefore, only main effects are presented (Table 1). Plane of nutrition in early and mid-pregnancy had no effect on any parameter of meat quality (P > 0.05). Selenium supplementation had a significant effect on meat colour with lambs from selenium-treated ewes having increased redness values (a*) of the muscle compared with controls (P < 0.05). A similar tendency was observed for metric chroma values (P = 0.072). Selenium supplementation of ewes had no effects on the sarcomere length, ultimate pH, cooking loss or WBSF of male lambs (P > 0.05).

Table 1 Effect of plane of nutrition and selenium supplementation in early and mid pregnancy on meat quality of offspring

	Early pregnancy nutrition				Mid-pregnancy nutrition			Selenium supplementation			Significance†
	L	M	H	s.e.d.	M	H	s.e.d.	Control	Treated	s.e.d.	Selenium
Colour‡											
L*	42.0	39.8	40.9	2.700	40.5	41.3	2.189	42.2	39.6	2.155	
a*	11.5	11.4	13.2	1.329	12.4	11.7	1.060	11.0	13.0	1.044	*
b*	11.2	11.1	11.1	0.681	11.1	11.2	0.539	10.9	11.4	0.531	
Hue	45.6	44.7	40.8	3.296	42.5	44.9	2.617	45.5	41.9	2.579	
Chroma	16.3	16.0	17.4	1.252	16.8	16.4	0.998	15.7	17.5	0.983	P=0.072
Sarcomere length (mm)	1.78	1.78	1.76	0.029	1.77	1.78	0.023	1.76	1.78	0.023	
Ultimate pH	5.63	5.59	5.63	0.037	5.61	5.63	0.029	5.62	5.61	0.029	
Cooking loss (%)	23.2	22.8	22.8	1.235	23.3	22.6	0.989	22.7	23.2	0.971	
WBSF (kg/cm^2)	1.73	1.83	1.65	0.174	1.67	1.81	0.143	1.77	1.71	0.154	

‡Illuminant D65, 2 degree observer; L* lightness, a* redness, b* yellowness, Hue = $\tan^{-1}(b^*/a^*)$, Chroma = $(a^{*2}+b^{*2})^{0.5}$
†There was no statistical significance between early and mid-pregnancy treatments; * = P < 0.05.

Conclusion Selenium supplementation of ewes throughout pregnancy, compared with supplementation only in late pregnancy, improved meat appearance by maintaining the redness of the muscle. This could have implications in prolonging meat shelf-life. Plane of nutrition in early and mid-pregnancy of dams had no effects on offspring meat quality.

Acknowledgements This study was supported by Programme Alβan (scholarship Nº E04D047780CL) and DARDNI

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