EFFECTS OF INCORPORATING YELLOW LUPINS INTO CONCENTRATE DIETS COMPARED WITH SOYA ON MILK PRODUCTION AND MILK COMPOSITION WHEN OFFERED TO DAIRY COWS

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ABSTRACT

An experiment investigated the hypothesis that incorporating lupins (*Lupinus* spp.) compared with soya bean (*Glycine max*) meal into concentrate diets would not alter the yield or composition of milk from dairy cows. There were 2 dietary treatments: yellow lupin (cv. Wodjil) and soya bean meal. The experiment consisted of a continuous design with 3 phases: a covariate period (weeks 2 and 3 of lactation), an adaptation period (7 days; week 4 of lactation) and a measurement period (weeks 5 to 12 of lactation). Twenty-four mature autumn-calving dairy cows were used. During the covariate period, feed intakes and milk yields were recorded whilst cows were offered ryegrass silage *ad libitum* plus 6 kg d^{-1} of a standard dairy concentrate. Cows were allocated to treatment and adapted to their respective diet over 7 days, during which the concentrate offered was increased up to 9 kg d^{-1}. During the measurement period, cows received ryegrass silage *ad libitum* using individual feeders. Concentrates of each treatment (9 kg d^{-1}) were fed 3 times d^{-1}. Milk yields were measured and 50 ml sub-samples of milk from two consecutive milkings were collected from all cows every week for measurement of fat, protein, lactose and somatic cell counts. Dairy cows offered the soya bean meal concentrate had a higher DM intake, and therefore, ME intake than cows offered the lupin dietary treatment but there was no difference in the N intake by cows on the two treatment diets. As animals on both dietary treatments consumed the same (9 kg) amount of concentrates each day, the intake data showed that dairy cows offered concentrates containing soya bean meal consumed more ryegrass silage than those offered concentrates containing yellow lupins. There were no significant differences in the milk yield or milk composition from dairy cows offered concentrate diets containing either yellow lupins or soya bean meal during weeks 5 to 12 of lactation ($P > 0.05$). Overall, the findings from this study indicate that yellow lupins could be used as a home-grown alternative to imported soya in dairy diets in the UK but further studies are needed to determine the long-term effects of yellow lupins on dairy cow health and fertility.

KEYWORDS

Lupinus luteus, ruminant feed, dairy production, milk composition

INTRODUCTION

In pursuit of sustainable and economically-viable farming systems, there is a need for livestock farmers to reduce reliance on imported feedstuffs, such as soya bean (*Glycine max*), which are subject to world market price fluctuations and have a high environmental footprint. Consequently, livestock farmers worldwide are under increasing pressure to maximise their use of home-grown feeds. In the EU feed sector alone, soya meal constituted 53% of the total protein supplement used in 2001 (Brookes, 2002). In 2004, approximately 732,177 t of soya beans, 22,891 t of soya oil and 6,905 t of soya meal were imported in the UK (Defra, 2006). In addition to this, there has been an increase in the EU and UK market demand for livestock products from systems based on traceable, non-genetically modified sources of protein in animal feed as a result of an increase in consumer awareness for food safety. Lupins (*Lupinus* spp.) as a high protein, high energy, nitrogen-fixing grain legume, have the potential to be used as a home-grown feedstuff to replace soya in livestock feeds in the UK. Lupins are not traditionally grown as a field crop in the UK but the high nutritional value of the grain, with both a high protein and oil concentration (White *et al.* 2007) and the development of modern varieties bred to contain low concentrations of alkaloids (Petterson *et al*. 1997) has led to a renewed interest in their potential as a feed in UK livestock diets (Wilkins and Jones, 2000). Typically the predominant lupin species fed to dairy cows in Europe and the USA is the

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white lupin (*Lupinus albus*) (White *et al.* 2007). It has been shown that white lupins can be used to replace soya as a protein supplement for lactating dairy cows (May *et al*. 1993). However, research has shown there are advantages of growing spring-sown yellow lupins in the UK, due to lower weed control needs and a lower risk of plant loss overwinter (R. Fychan, pers. comm.), compared with autumn-sown white lupins (Shield *et al.* 2000). However, there have been few reports on the use of yellow lupins as a replacement for soya in the diet of lactating dairy cows (van Barnevald, 1999). In the current study the effects of feeding concentrate diets incorporating yellow lupin compared with soya bean meal on intakes, milk productivity and milk composition in dairy cows.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN, TREATMENTS, ANIMALS AND ALLOCATIONS

Two groups of animals were offered the same silage but were supplemented with concentrate feeds containing either yellow lupin (cv. Wodjil) or soya bean meal as the protein source. The experiment consisted of a continuous design of 2 dietary treatments, with 12 lactating cows on each treatment. The experiment was divided into 3 phases: a covariate period (weeks 2 and 3 of lactation), an adaptation period (week 4 of lactation) and a measurement period (weeks 5–12 of lactation). Yellow lupin grain or soya bean meal was incorporated into 2 basal concentrate diets (pelleted), with a target crude protein (CP) concentration of 264 g kg DM^{-1} and a metabolisable energy (ME) value of 13.4 MJ kg DM^{-1}. Yellow lupins or soya bean meal formed 32 per cent of the total ingredients in each treatment diet. Twenty-four mature lactating dairy cows were used for the experiment. Milk yields were recorded during week 2 and 3 of lactation to provide a covariate for each animal and cows were allocated to each treatment on the basis of their calving date, parity, previous milk yield, covariate milk yield, live weight and body condition.

EXPERIMENTAL APPROACH AND MEASUREMENTS

Autumn-calving cows were housed in one group during the winter months and fed using Hoko roughage intake control feeders. Hybrid ryegrass silage (first cut) was offered ad libitum, defined as at least 10% (fresh) above the unrestricted daily consumption. During the covariate period of two weeks (week 2 and 3 of lactation), a standard diet of ad libitum ryegrass silage and 6 kg d^{-1} of standard dairy concentrate was offered to all cows and feed intakes and milk yields were recorded. Animals were then allocated to treatment, adapted to their respective treatment concentrate diet over 7 days and the amount of concentrate offered was increased to 9 kg d^{-1}. During the measurement period (week 5–12 of lactation), cows continued to receive ryegrass silage ad libitum using Hoko feeders. Concentrates of each dietary treatment (9 kg d^{-1} $animal^{-1}$) were fed 3 times a day. Fresh silage and concentrates as offered were DM sampled, with sub-samples of the feed offered being bulked, freeze dried and ground for chemical analysis for each week of the measurement period. All animals were weighed daily and scored for body condition weekly throughout the experiment. Cows were milked at approximately the same times each day and their milk yields measured. Milk samples from two consecutive milkings were collected from all cows every week to determine milk fat, protein and lactose concentrations. Data were analysed as repeated measures on Genstat® by REML, assuming an auto-regressive correlation structure.

RESULTS AND DISCUSSION

DIET COMPOSITION AND INTAKES

The dry matter content of the concentrate diets were 846 and 851 g kg $freshweight^{-1}$ for the yellow lupin and soya bean meal diets, respectively. The nitrogen concentration of the yellow lupin diet was 44.1 g kg DM^{-1} and the nitrogen concentration of the soya bean meal diet was 41.1 g kg DM^{-1}. Both nitrogen values were slightly lower than the target CP concentration in the formulations but were within an acceptable range. The ME concentration of both concentrate diets was 12.8 MJ kg DM^{-1}. The DM intakes, N intakes and ME intakes of the cows are presented in Table 1. Dairy cows offered the soya bean meal concentrates had a higher DM intake, and therefore, ME intake than cows offered the lupin dietary treatment but there was no difference in the N intake by cows on the two treatment diets. As animals on both dietary treatments consumed the same (9 kg) amount of concentrates each day, the intake data showed that dairy cows offered concentrates containing soya bean meal consumed more ryegrass silage than those offered concentrates containing yellow lupins.

MILK YIELDS AND MILK COMPOSITION

There were no significant differences in the milk yield or milk composition of dairy cows offered concentrate diets containing either yellow lupins or soya bean meal during weeks 5 to 12 of lactation (Table 2). Overall, the findings from this study indicate that yellow lupins could be used as a home-grown alternative source to imported soya in dairy diets in the UK. Further studies are now needed to determine the long-term effects of yellow lupins and dairy cow productivity, health and fertility to effectively determine their full potential for use within the UK dairy industry.

Table 1. Mean total intakes of dry matter (DM), metabolisable energy (ME) and nitrogen (N) by dairy cows offered *ad libitum* ryegrass silage and 9 kg d^{-1} of concentrates incorporating either yellow lupins or soya bean meal during weeks 5 to 12 of lactation.

	Yellow lupins	Soya bean meal	s.e. of difference	Level of significance
Intake				
DM (kg DM d^{-1})	18.3	19.3	0.32	**
ME (MJ kg DM^{-1})	203	215	3.64	**
N (kg d^{-1})	0.62	0.62	0.012	ns

ns – not significant; ** – $P < 0.01$.

Table 2. Mean milk yield (kg d^{-1}) and milk composition (g kg^{-1}) of dairy cows offered *ad libitum* ryegrass silage and 9 kg d^{-1} of concentrates incorporating either yellow lupins or soya bean meal during weeks 5 to 12 of lactation.

	Yellow lupins	Soya bean meal	s.e. of difference	Level of significance
Milk yield	30.1	31.9	1.35	ns
Fat	39.8	37.4	1.42	ns
Protein	28.9	29.9	0.54	ns
Lactose	46.4	45.9	0.36	ns

ns – not significant.

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LITERATURE CITED

Brookes, G. 2001. GM and non GM ingredient market dynamics and implications for the feed industry. Feed Compounder 21: 18-21.

Defra, 2006. SCP Evidence base: Sustainable commodities Case Studies: SOYA. http://www.defra.gov.uk/science/Project_Data/DocumentLibrary/EV02019/EV02019_6090_FRA.pdf (accessed 04/06/08).

May, M.G., D.E. Otterby, J.G. Linn, W.P. Hansen, D.G. Johnson, and D.H. Putnam. 1993. Lupins (*Lupinus alba*) as a protein supplement for lactating dairy cows. Journal of Dairy Science 76: 2682-2691.

Petterson, D.S., S. Sipsas and J.B. Mackintosh. 1997. The chemical composition and nutritive value of Australian pulses. Grains Research and Development Corporation, Canberra, Australia.

Shield, I.F., T. Scott, H.J. Stevenson, J.E. Leach and A.D. Tood. 2000. The causes of over-winter plant losses of autumn-sown white lupins (*Lupinus albus*) in different regions of the UK over three seasons. Journal of Agricultural Science 135: 173-183.

White, C.L., V.E. Staines and M. vH Staines. 2007. A review of the nutritional value of lupins for dairy cows. Australian Journal of Agricultural Research 58: 185-202.

Wilkins, R.J. and R. Jones. 2000. Alternative protein sources for ruminants in the United Kingdom. Animal Feed Science and Technology 85: 23-32.

Van Barneveld, R.J. 1999. Understanding the nutritional chemistry of lupin (*Lupinus* spp.) seed to improve livestock production efficiency. Nutrition Research Reviews 12: 203-230.