Report for Protein Research Trust

Evaluation of lupins for pig feeding

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2002

Background

In 1999 a pig growth trial was conducted to investigate the usage of lupins in pig diets. Forty eight pigs between 20 and 50kg body weight were subjected to one of six dietary treatments designed to evaluate full-fat lupins as a protein and energy source. Graded levels of lupins were included in the feed, from zero in Basal A to 400g/kg in Basal B, with blends of these two basal feeds producing the three intermediate treatments. The treatment with the highest inclusion of lupins was unacceptable to the pigs, and after a few weeks had to be withdrawn from the experiment. The next-highest lupin treatment, containing 300g lupin/kg diet, supported reasonable growth. Where a choice was offered between feeds containing soya versus lupins, the overwhelming choice was in favour of soya. Whole lupin meal proved to be unpopular to pigs when given a choice. However, it is possible that the anti-nutritional factor(s) limiting the usage of lupin as an alternative protein source may reside in the hulls of the lupin seed. To ascertain whether the anti-nutritional factors resided in the seed coat or in the cotyledons a further series of experiments were required. In addition relevant analyses on the hulls and cotyledons, and on the food processing organs of pigs that have been fed diets containing either the hulls or the cotyledons of lupins need to be conducted. This will assist in identifying which anti-nutritional factors are involved, and what effect they are having on different parts of the gut, the pancreas, liver and blood.

Experimental Design

Two different varieties of lupins were be tested: *Lupinus angustifolius and Lupinus albus*, in two separate experiments. The design of the experiments were exactly the same.

Forty eight pigs were grown for seven weeks from an average starting weight of 14.8 kg. The average final weight was 45.0 kg. The animals were kept on a range of diets designed to measure the response to lupin hulls, lupin cotyledons, or both. Three basal diets were formulated, one without lupins (containing soybean meal (SOYA)), the second with about 30% full fat, dehulled lupin seed (LUPIN), and the third being the same as the first but replacing 5% sunflower husks with lupin hulls (SOYA+HULLS) (Table 1). These three feeds were fed alone, and blended in appropriate proportions, to produce a series of nine feeds containing different dehulled lupin and lupin hull contents (Table 2). The hypothesis was that if the anti-nutritional factors resided in the hulls only, then diluting the soybean with dehulled lupin seed will have no effect on the performance of the pigs, but that at all levels of lupin inclusion, where lupin hulls have been added back to the feed, performance will be adversely affected. Weight gains and food intakes were be measured throughout the trial.

Fifteen pigs were slaughtered at the end of the experiment, and the pancreas and ileum content were extracted and frozen. These 15 pigs were comprised of three pigs each from the following treatments:

T1, T3, T5, T6 and T8. A series of chemical analysis associated with pancreatic and gut function were conducted on the samples. The analyses included measurements of non-starch polysaccharides (NSP's), starch, oligosaccharides, alkaloids, as well as the standard proximate analysis of whole seeds, cotyledons and hulls (DE, amino acids, crude protein).

To test for significant differences between the main effects and interaction of the treatments the data were analyzed using analysis of variance in Genstat. Simple linear regression analyses were also conducted to measure the responses in ADG, FI and FCE to increasing inclusion levels of dehulled lupin meal and lupin hulls. To determine whether there were any differences in the choices the pigs made between the three different basal diets, One sample Student t-tests were conducted.

Results

Performance

There were no significant interactions between treatments and sex and therefore only the main effects will be reported. Initial body weight was a significant covariate and therefore reported means have been adjusted for the covariate. The main effects of dietary treatments and sex are shown in Table 3. Only the sex of the animal had an effect on the growth rate (ADG) and food intake (FI) in pigs fed treatments containing the *L. angustifolius* variety. However, when *L. albus* was fed there were significanct differences in ADG and FI between pigs fed different levels of dehulled lupin and lupin hulls. The ADG response to increased dietary concentrations of dehulled lupin meal, irrespective of the variety, showed a linear decline (Figure 1 and 2), except in treatments where *L angustifolius* hulls were added the response was quadratic rather than linear. Food intake decreased linearly as concentrations of dehulled *L. albus* increased, but not when *L angustifolius* increased (Figure 3 and 4). Adding *L albus* hulls did affect the FI response to dehulled lupin concentration by eliminating any differences between concentrations (Figure 4). However, adding *L angustifolius* hulls did not alter the response in FI (Figure 3). The response in FCE to increased levels of dietary dehulled lupin meal (up to 30%) and to dietary lupin hulls (up to 5%) were not significant.

Preferences

When offered a choice between a diet with soya versus a diet with dehulled lupins, pigs consistently chose between 87 and 99% soya based diets even if they contained 5% lupin hulls (Table 4 and 5). There was no difference in the proportion eaten when offered a choice between soya with or without lupin hulls, irrespective of the variety. From this evidence it would appear that the source of the anti-nutritional factor is in the kernel rather than in the hull.

Chemical composition

The chemical composition of the kernel and hulls is shown in Table 6. The concentration of total non-structural carbohydrates (TNC) in the kernel of the two species was similar but the TNC content of *L. albus* hulls was relatively lower than that in *L. angustifolius*. The kernel was the principal source of TNC, starch, non-starch polysaccharides (NSP) and oligosaccharides. *L. albus* contained slightly higher amounts of NSP than *L. angustifolius*. The alkaloid content of both seedmeals was below the thresh-hold level of toxicity in growing pigs. In both varieties, hulls contained relatively more alkaloid levels than the kernel even though T6 (SOYA+HULLS) using *L angustifolius*, had a lower level than T1 (SOYA alone). The inverse occurred when using *L albus*. In both cases, T5 (30% LUPIN) had at least a 50% higher alkaloid concentration than T1 (SOYA). The differences in alkaloid content of treatment diets between lupin varieties may be responsible for the response in FI, with the high level of alkaloid found in T6 relative to T1 of *L. albus* causing a reduction in FI. When L angustifolius was used T6 (SOYA+HULLS) had 88% of the alkaloid levels found in T1 (SOYA only) and therefore FI was not as negatively or positively affected by the inclusion of lupin hulls. It is also possible that the lower starch and TNC content in the diets with dehulled lupin (T5), could have contributed to the reduced growth rate. These lower values, in turn, could have been a result of the higher wheat middling content in dehulled lupin diets.

Digestive enzymes

The analyses on the *L. albus* dietary treatments are still in progress and therefore only the results of the first trial (*L. angustifolius*) will be presented. There were no significant effects of dietary treatment on tissue protein content or the activities of digestive enzymes in the pancreas (Table 7). The protein content of the duodenal mucosa and activity of maltase in the small intestine also did not vary with diets. However, sucrase activity was significantly affected ($P<0.05$) by the treatments but did not follow any pattern (Table 8).

Conclusion

Increasing the dehulled lupin content of diets without lupin hulls from 0 to 300 g/kg, caused a consistent linear decrease in the growth rate and, in the case of the *L albus* variety, a similar decrease in food intake. Likewise, when the animials were given a choice between a diet with or without dehulled lupin, there was an overwhelming preference for a diet without dehulled lupin. These results would suggest that some anti-nutritional factor(s) resides in the kernel. The chemical composition of the diets is not conclusive to indicate what is the anti-nutritional factor, although the concentrations of both alkaloids and oligosaccharides were higher in the diets with dehulled lupin relative to those without. Adding lupin hulls back to diets with different levels of dehulled lupin did effect the performance but not in any consistant way. For example, growth rates in pigs fed *L angustifolius* were generally higher when lupin hulls were added, whereas those fed *L. albus* showed no difference in growth when hulls were added. The addition of *L albus* hulls did reduce the feed intake appearing to nullify the effect of the presence of dehulled lupin in the diet. Although not conclusive it would appear that the inclusion of hulls (at 5%), especially the variety *L albus*, did affect the performance of growing pigs due to the higher levels of alkaloids found in the *L albus* hull.