LUPIN OLIGOSACCHARIDES: NUTRIENTS OR ANTI-NUTRIENTS?

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Summary

Two AME bioassay studies were conducted to evaluate the nutritive value of ethanol extracted lupin meal. In experiment 1, groups of four birds per cage were fed four semi-purified diets containing untreated and oligosaccharide-reduced, ethanol extracted lupin meal from two cultivars of L. angustifolius (cv Gungurru and cv Danja). No significant differences in feed conversion and excreta moisture content were observed among the diets. AME was significantly reduced in diets containing ethanol extracted lupin kernels. Ileal digesta viscosity was significantly increased by removal of oligosaccharides. The second experiment was conducted as a single bird AME bioassay involving four dietary treatments: untreated and ethanol extracted meals of two lupin species (L. angustifolius cv Gungurru and L. albus cv Kiev mutant). AME and dry matter digestibility of L. angustifolius was significantly reduced by removal of oligosaccharides. No such differences were found in diets containing L. albus.

I. INTRODUCTION

The lupin species grown in Australia contain low levels of alkaloids making them more suitable for inclusion in pig and poultry diets. High levels of oligosaccharides (OS), in particular α-galactosides, limit their inclusion rate in these diets. Due to a lack of endogenous α-galactosidase monogastric animals cannot digest α-galactosides. Bacterial degradation of α-galactosides in the hindgut can lead to increased fluid retention, increased hydrogen production and can impair the utilisation of nutrients (Saini, 1989). However, the nutritive value of legume α-galactosides in broiler diets remains unclear. Ethanol removal of OS from soyabean increased nitrogen corrected true metabolisable energy (TMEₙ) (Coon et al., 1990) whereas ethanol extraction of canola meal resulted in a decrease of TMEₙ (Slominski et al., 1994). There is little information available on the effects of lupin oligosaccharides on energy availability in broiler diets. The inclusion of 30 g/kg dried α-galactosides from L. albus had no effect on bird performance or nutrient digestibility on the jejunum and ileum (Brenes et al., 1989).

This paper reports the results of two studies measuring the effect of oligosaccharides from lupins on performance, apparent metabolisable energy and gut viscosity in broilers.

II. MATERIALS AND METHODS

(a) Preparation of oligosaccharide-free lupin meal

The first experiment included meal from two cultivars of L. angustifolius. These were Gungurru and Danja. In experiment 2, kernel of the two lupin species L. angustifolius cv Gungurru and L. albus cv Kiev mutant were used. In both experiments lupin kernels were

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finely ground and oligosaccharides were extracted in 80% ethanol using a modified procedure described by Coon et al., (1990).

(b) **Experiment 1**

(i) *Diet formulation.* Lupin kernel (untreated or ethanol-extracted) was included at 300 g/kg in a semi-purified diet based on sorghum and casein (sorghum 543 g/kg, casein 91 g/kg) and vitamin and minerals 66 g/kg. The basal diet without lupin was included as a control. Each diet was cold pelleted and replicated six times in a randomised block design.

(ii) *AME trial.* The AME study was conducted at the Parafield Poultry Research Centre, Adelaide. Day old mixed sex broiler chickens (Ingham IM98) were raised to 24 days of age in floor pens on commercial starter crumbles. At the start of the AME study birds were weighed in groups of four (two males and two females) and transferred to metabolism cages. A three day period during which feed intake was measured enabled the birds to adapt to their new environment. During the following four days feed intake was measured and all excreta was collected. Excreta moisture content of excreta voided during the second day of the collection period was measured. At the end of the 7 day experimental period all birds were weighed. Two birds from each cage (one male, one female) were killed by intravenous injection of pentobarbitone and ileal digesta were pooled and kept on ice prior to centrifugation then measurement of viscosity.

(c) **Experiment 2**

(i) *Diet formulation.* Four semi-purified diets based on sorghum (550 g/kg) and starch (29 g/kg) were prepared with 350 g/kg untreated and ethanol extracted lupin meal. The diets had originally been used in a study to investigate the effects of lupin oligosaccharides on energy digestion in growing pigs (van Barneveld et al., 1996). In the current study additional methionine and lysine were added to meet the nutritional requirements of broilers. Each diet was cold pelleted and replicated twelve times in a randomised block design.

(ii) *AME trial.* The AME study was conducted at the Pig and Poultry Production Institute, Roseworthy. Day old mixed sex broiler chickens (Ingham IM98) were raised to 20 days of age in floor pens on commercial starter crumbles. The birds were transferred at 20 days of age two per cage to individual metabolism cages and given two days to adapt to the new environment. At 22 days of age, one bird was removed from each cage. The remaining chickens were weighed individually. Other procedures were the same as for Experiment 1. At the end of the 7-day experimental period, all birds were weighed individually.

(d) **Viscosity measurement and analysis of feed and excreta**

Ileal samples were centrifuged at 10,000 g for 10 minutes. Viscosity of supernatant was measured in the CSIRO Glenthorne laboratories, Division of Human Nutrition, Adelaide, with a Brookfield DVIII rheometer at 25°C with a CP40 cone and shear rate of 5 – 500 s⁻¹. Gross energy of excreta and milled feed was measured using a Parr isoperibol bomb calorimeter. Dry matter content of each sample of lupin, and pelleted and milled feed was determined by drying at 105°C.
III. RESULTS

(a) Experiment 1

The removal of oligosaccharides by ethanol extraction significantly ($P<0.05$) reduced AME of the diet and increased ileal viscosity regardless of the lupin cultivar (Table 1). No significant effects were measured for the feed conversion ration (FCR) and the excreta moisture content.

Table 1. Feed conversion (FCR, g feed/g gain), dietary apparent metabolisable energy (AME, MJ/kg dry matter), excreta moisture content (EM, g/kg)) and ileal viscosity (IV, cP) of untreated and ethanol-extracted lupin kernel meal (n=6; means ± SD).

<table>
<thead>
<tr>
<th>Lupin cultivar</th>
<th>Ethanol extraction</th>
<th>FCR</th>
<th>AME MJ/kg DM</th>
<th>IV cP</th>
<th>EM g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gungurru</td>
<td>No</td>
<td>2.01±0.08</td>
<td>13.8±0.3b</td>
<td>6.8±4.0c</td>
<td>730±20</td>
</tr>
<tr>
<td>Gungurru</td>
<td>Yes</td>
<td>2.15±0.25</td>
<td>13.0±0.3c</td>
<td>15.2±10.2ab</td>
<td>740±30</td>
</tr>
<tr>
<td>Danja</td>
<td>No</td>
<td>2.04±0.06</td>
<td>13.4±0.3b</td>
<td>8.4±3.0bc</td>
<td>740±30</td>
</tr>
<tr>
<td>Danja</td>
<td>Yes</td>
<td>2.13±0.19</td>
<td>12.6±0.5c</td>
<td>17.6±7.0a</td>
<td>740±30</td>
</tr>
<tr>
<td>Sorghum control</td>
<td></td>
<td>2.12±0.09</td>
<td>15.4±0.2a</td>
<td>3.0±0.6c</td>
<td>570±40</td>
</tr>
</tbody>
</table>

abc Means with a common superscript are not significantly different ($P<0.05$).

(b) Experiment 2

AME of diet and dry matter digestibility in the diet containing ethanol-extracted *L. angustifolius* was significantly ($P<0.05$) lower than in the diet with untreated lupins (Table 2). No such differences were found between diets containing ethanol-extracted or untreated *L. albus*. Chickens fed *L. albus* had a significantly better FCR than chickens receiving *L. angustifolius*.

Table 2. Feed conversion (FCR, g feed/g gain), dietary apparent metabolisable energy (AME), excreta moisture content (EM) and dry matter digestibility (DMd, g/g) of untreated and ethanol extracted lupin kernel meal (n=12; means ± SD).

<table>
<thead>
<tr>
<th>Lupin species</th>
<th>Cultivar</th>
<th>Ethanol extraction</th>
<th>FCR</th>
<th>AME MJ/kg DM</th>
<th>EM (g/kg)</th>
<th>DMd</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. angustifolius</em></td>
<td>Gungurru</td>
<td>No</td>
<td>1.78±0.13a</td>
<td>13.4±0.6a</td>
<td>720±40</td>
<td>0.64±0.03a</td>
</tr>
<tr>
<td><em>L. angustifolius</em></td>
<td>Gungurru</td>
<td>Yes</td>
<td>1.86±0.19a</td>
<td>12.1±0.9b</td>
<td>740±30</td>
<td>0.58±0.04b</td>
</tr>
<tr>
<td><em>L. albus</em></td>
<td>Kiev</td>
<td>No</td>
<td>1.64±0.07b</td>
<td>14.2±1.0a</td>
<td>700±80</td>
<td>0.66±0.04a</td>
</tr>
<tr>
<td><em>L. albus</em></td>
<td>Kiev</td>
<td>Yes</td>
<td>1.62±0.19b</td>
<td>13.7±1.2a</td>
<td>720±60</td>
<td>0.63±0.04a</td>
</tr>
</tbody>
</table>

abc Means with a common superscript are not significantly different ($P<0.05$).

IV. DISCUSSION

Diets containing ethanol treated *L. angustifolius* lupin meal had significantly lower AME than diets containing the untreated lupins. This result indicates that OS in these lupins species actually contributed to the energy in broiler diets rather than having anti-nutritive effects. This result is even more surprising considering the significant increase in ileal
viscosity in digesta of birds fed the extracted lupin meal. Increased viscosity is regarded as a cause for decreased nutrient absorption (Smits et al., 1997). However, in the second experiment, the ethanol extraction of \textit{L. angustifolius} meal resulted in a significantly higher apparent DM digestibility in comparison to the untreated meal, which is the likely cause for the increase of AME.

In diets containing \textit{L. albus} the ethanol extraction did not significantly change AME or DM digestibility. Although not statistically significant, there was also a numerical decline in energy and DM digestibility with ethanol removal of OS. The reason for the differences between the two lupin species is not clear. The ethanol treatment might have had different effects on the nutritive value of the two lupin species due to differences in composition of di- and tri-saccharides (Saini and Gladstones, 1986) and differences in cell wall structures between the two species.

Chickens were able to utilise the higher AME of \textit{L. albus} for a better feed conversion. However, regardless of lupin cultivar or lupin species the bird performance was not affected by ethanol treatment.

No differences in excreta moisture content were found when chickens were fed untreated or ethanol extracted lupins. A possible increase in bacterial degradation of \(\alpha\)-galactosides in the hindgut of birds fed untreated meal was not associated with any increase in fluid retention.

The results of these two studies indicate that OS in \textit{L. angustifolius} kernels contributed to the apparent metabolisable energy in broiler diets. OS in this lupin species are not as severely anti-nutritive as previously thought.

REFERENCES


