Chemical composition and standardised ileal digestible amino acid contents of Lathyrus (*Lathyrus cicera*) as an ingredient in pig diets


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Abstract

*Lathyrus cicera* is a grain legume that is well adapted to grow in low rainfall regions. However, it contains a neurotoxin, 3-(N-oxylyl)-L-2,3-diaminopropionic acid (ODAP), which can cause paralysis of the lower limbs, known as “lathyrism”. An experiment was conducted to measure the nutrient content and ileal digestible amino acid content of a recently released low ODAP lathyrus variety Chalus. Chemical analyses and total tract nutrient digestibility showed that the new lathyrus variety Chalus contained 0.09% ODAP, 265 g/kg
crude protein and 13.5 MJ digestible energy per kg on an as-fed basis. The ileal digestible nutrient content of Chalus was measured with six grower pigs (Large White x Landrace, 43±0.3 kg) fitted with a simple T-piece cannula. The Chalus contained 12.9, 1.4 and 5.4 g/kg of apparent ileal digestible lysine, methionine and threonine, respectively. Standardised ileal digestible amino acid content was calculated using published endogenous amino acid losses determined in 34-kg growing pigs under a protein-free method. The Chalus contained 14.3, 1.5 and 6.0 g/kg of standardised ileal digestible lysine, methionine and threonine, respectively.

Key words: Pigs, Lathyrus cicera, Energy, Amino Acids, Digestibility

1. Introduction

Many plant legumes have relatively high levels of crude protein, but the unbalanced amino acid profile such as lower sulphur amino acids and the lower availability of sulphur amino acids often means that the nutritional value of legumes for the pig is low. Furthermore, legumes often contain anti-nutritional factors (ANF) that act as a self-defense mechanism for the plant, but which can cause production problems when fed to animals (Kim et al., 2007; Mekbungwan, 2007). Therefore, before any legume can be considered as a suitable source of nutrients it is important to know its nutrient composition and to then evaluate animal performance when fed increasing levels of the particular legume in question.

Lathyrus cicera (also referred to as dwarf chickling or vetchling) and L. sativus (grasspea) are two closely related species of grain legumes that are well adapted to being grown in low rainfall regions (250 – 500 mm/year), particularly on fine textured neutral to alkaline soils. Seeds are about half the size of a field pea and have an angular, blocky appearance. The nutrient composition of L. cicera and L. sativus is similar to that of other legumes such as field peas (Pisum sativum), with crude protein contents of 250 and 270 g/kg, respectively (Hanbury et al., 2000). However, they both contain a neurotoxin, 3-(N-oxalyl)-L-2,3-
diaminopropionic acid (ODAP) which can cause paralysis of the lower limbs, known as “lathyrism” (Hanbury et al., 2000). Emphasis in breeding programs has concentrated on reducing the concentration of ODAP, for example from 7.20 to 0.30 g/kg in Canadian studies (Castell et al., 1994), but the use of this legume in animal diets is still limited.

Recent research has produced seed of *L. cicera* cv Chalus with a reduced concentration of ODAP and improved agronomic features for greater yield (Hanbury et al., 2000). The concentration of ODAP is 50% lower than the average in a larger number of unimproved lines (0.18%; Hanbury et al., 2000), but it still contains other ANF, for example higher trypsin inhibitor activity than that of narrow leafed lupins (*L. angustifolius*) (2.07 vs 0.13 g/kg, respectively; White et al., 2002). For example, Castell et al. (1994) reported a significant linear reduction in voluntary food intake and growth rate when grower pigs were fed diets containing 0, 100, 200, 300 or 400 g/kg of *L. sativus* seeds with 0.3 g/kg ODAP. However, feeding trials conducted with the low ODAP variety Chalus showed that Chalus can be included up to 150 g/kg in weaner diet (Trezona et al., 2000) and up to 300 g/kg in grower finisher diets (Mullan et al., 1999) without compromising performance, slaughter characteristics and organ weights.

Therefore, the aim of this experiment was to measure the nutrient content, ileal and total tract energy digestibility, and apparent and standardised ileal amino acid digestibility of a recently released variety of *L. cicera* (cv. Chalus) to provide complete digestible nutrient profiles for formulation of pig diets using this ingredient. The hypothesis tested was the new low ODAP *L. cicera* cv. Chalus would contain comparable amounts of standardised ileal digestible amino acids to field peas.
2. Materials and methods

Proximate analysis of the Chalus seed used in the animal experiments was analysed using the methods of the AOAC (1984). Gross energy was determined by adiabatic bomb calorimetry and acid-insoluble ash was determined using the method described by Choct et al. (1992) by hydrolysing ashed samples in 4 M HCl and gravimetrically recovering acid insoluble ash.

Amino acids in the grain and legumes, mixed diets and ileal digesta were measured by ion-exchange chromatography following a 24 h hydrolysis at 110 °C with constant boiling point 6 M HCl under N2 and measured after reaction with ninhydrin. Norleucine was used as an internal standard with accepted recoveries falling between ±0.025 g/kg of the batch mean.

Methionine and cystine in the cereals only were measured following preoxidation of the samples with performic acid before hydrolysis and subsequent measurement as methionine sulphone and cysteic acid, respectively (van Barneveld et al., 1998). Activities of trypsin inhibitor and chymotrypsin inhibitor were measured spectrophotometrically (White et al., 2002), and ODAP contents of Chalus were analysed by capillary zone electrophorosis using the method described by White et al. (2002).

The ileal digestibility of amino acids and the digestible energy (DE) content of Chalus were determined using six Large White x Landrace entire male pigs. The study was based on a Latin square design with 6 replications. Six pigs weighing 43 ± 0.3 kg (mean ± standard error of mean, SEM) were sourced from a high health status commercial piggery and surgically inserted with a simple T-piece cannula at the 15 cm anterior to the ileo-caecal junction according to the procedure detailed by van Barneveld et al. (1998). After surgery pigs were housed in group pens and fed a commercial grower diet (14.0 MJ DE/kg, 10.5 g standardised ileal digestible lysine/kg) for a recovery period of seven days. Pigs in group pens during the recovery period had no incidence involving violence and injury around the cannula. Pigs were then moved and housed individually in metabolism cages, where the experimental diets were introduced over a 3-day transition period and then for a further five days for adaptation before
collection of ileal digesta. A diet containing triticale (940 g/kg) was used as the standard, with
the Chalus treatment being where 35% of the triticale was replaced by Chalus by direct
substitution. Other additives included in the diets were 5 g L lysine-HCl, 1 g choline chloride,
30 g dicalcium phosphate, 2.75 g salt, 1 g vitamin mineral premix and 20 g acid insoluble ash
marker/kg diet. The crude protein content of the diet was 158.8 g/kg in air-dry basis. Pigs
were fed at the level of three times maintenance energy \[3 \times (0.458 \times \text{bodyweight}^{0.75})/\text{diet DE}\],
with feed being provided in two equal amounts at 0800h and 1600h. Water was available \textit{ad
libitum} through a nipple drinker set in the crate. Continuous 8h collections of digesta were
taken over two consecutive days, and samples were immediately stored at -20ºC. Apparent
ileal amino acid digestibility of Chalus was calculated by differences in amino acid
digestibilities between the basal diet (triticale) and Chalus diet. Standardised ileal digestible
amino acid contents of Chalus were calculated using previously published endogenous amino
acid flows determined in 34 kg pigs under a protein-free method (Stein et al., 1999).

3. Results

The sample of Chalus contained 265 g/kg crude protein and 6 g/kg fat (Table 1). The
concentration of ODAP from the same batch of Chalus seed had previously been measured by
Hanbury et al. (2000) and was reported as 0.90%. The Chalus seed contained ANF at the
concentrations of 2.0 g/kg for trypsin inhibitor activity and 2.8 g/kg for chymotrypsin
inhibitor activity. Based on the ileal cannulation study, the determined ileal and total tract DE
content of Chalus was 9.0 and 13.5 MJ/kg, respectively, on an air-dry basis, with a ratio of
ileal DE:total tract DE of 0.67 (Table 2). The amino acid composition of Chalus seed is
reported in Table 5. The ileal digestibility of amino acids ranged between 52.5% for cystine
through to 87.1% for arginine. The ileal digestibility for lysine, methionine and threonine was
79.5, 69.3 and 62.4%, respectively. Calculated standardised ileal digestible lysine, methionine
and threonine of Chalus were 14.3, 1.5 and 6.0 g/kg, respectively.
4. Discussion

Whether an ingredient is included in the diet of pigs will depend on the unit price, content and availability of the various components, and in some cases the presence and level of ANF that may affect either feed intake or nutrient metabolism. The Chalus seed used in this experiment had a crude protein content of 265 g/kg (as-received basis) which is similar to that reported previously by Hanbury et al. (2000) (268 g/kg) but higher than that reported by White et al. (2002) (247 g/kg), Farhangi (1996) (236 g/kg) and Seabra et al. (2001) (229 g/kg). This compares to a mean value of 272 g/kg (range of 245 to 323 g/kg) for *L. sativus* from six studies reviewed by Hanbury et al. (2000). These results indicate that Chalus has a level of crude protein similar to that of Field peas and Faba beans, but lower than that for Lupins (322 g/kg) (Hanbury et al., 2000).

Data on the amino acid composition of Chalus have been provided by Farhangi (1996), Hanbury et al. (2000), Seabra et al. (2001) and White et al. (2002). There was close agreement in the amino acid composition with most studies, in particular that of Hanbury et al. (2000), White et al. (2002) and the results from the current study which all used Chalus sourced from the same environment and season. For these three studies, the average content of total lysine, methionine and threonine was 16.79, 2.03 and 8.96 g/kg, respectively, and these values should be used by the animal feed industry as a guide to the nutritional value of Chalus. As stated by Hanbury et al. (2000), the amino acid profile of Chalus is similar to that reported for many legumes, being relatively low in the sulphur-containing amino acids (methionine and cystine) but rich in lysine.

Measured apparent amino acid digestibility at the ileum in growing pigs ranged between 53% for cystine through to 87% for arginine. The apparent ileal digestibility for lysine, methionine and threonine was 77.5, 69.3 and 62.4%, respectively. Seabra et al. (2001) have also reported
apparent ileal digestibility values for *L. cicera* and reported values for lysine, methionine and threonine of 45.4, 42.0 and 46.1%, respectively, which are significantly lower values compared with values found in the present study. The different variety of *L. cicera* used in the two studies could be a possible explanation for the disparity. In addition, Seabra et al. (2001) used 10-kg pigs to measure apparent ileal amino acid digestibility whilst the present study used 46-kg pigs, which could have contributed to the disparity between ileal amino acid digestibilities in the two studies (Kim and Easter, 2001; Wilson and Leibholz, 1981). Nevertheless, the present study reports that the new low ODAP variety Chalus contained 14.3, 1.5 and 6.0 g/kg of standardised ileal digestible lysine, methionine and threonine, respectively, on an air-dry basis, which is comparable to the standardised amino acid contents in field peas (Sauvant et al., 2004).

The ileal and total tract apparent digestible energy contents of the Chalus seed used in this experiment were found to be 9.0 and 13.5 MJ/kg on an air-dry basis, with ileal DE:total tract DE ratio of 0.67. The only other value reported in the literature for *L. cicera* is that of Seabra et al. (2001) with a total tract apparent digestibility value for energy of 72.6% and an apparent ileal digestibility value for energy of 58.1%, which are comparable to our results (81.8 and 54.5%, respectively).

5. Conclusion

The new low ODAP variety of *L. cicera*, Chalus, contained 9.0 and 13.5 MJ/kg ileal and total tract DE, respectively. The standardised ileal digestible amino acid contents of Chalus were 14.3, 1.5 and 6.0 g/kg for lysine, methionine and threonine, respectively, which are comparable to that of field peas.
References


Table 1. Proximate analysis (g/kg, air-dry basis) and ileal and total tract digestible energy contents of *Lathyrus cicera* cv Chalus seed used in experimental diets

<table>
<thead>
<tr>
<th>Component</th>
<th>g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>905</td>
</tr>
<tr>
<td>Crude protein (N x 6.25)</td>
<td>265</td>
</tr>
<tr>
<td>Fat</td>
<td>6</td>
</tr>
<tr>
<td>Gross energy (MJ/kg)</td>
<td>16.5</td>
</tr>
<tr>
<td>Nitrogen free extract (NFE)*</td>
<td>538</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>63</td>
</tr>
<tr>
<td>Neutral-detergent fibre</td>
<td>175</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>96</td>
</tr>
<tr>
<td>Lignin</td>
<td>4</td>
</tr>
<tr>
<td>Ash</td>
<td>34</td>
</tr>
<tr>
<td>P</td>
<td>2.9</td>
</tr>
<tr>
<td>Ca</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Anti-nutritional factors
- ODAP\(^b\) 0.9
- Trypsin inhibitor activity 2.0
- Chymotrypsin inhibitor activity 2.8

Digestible energy content (MJ/kg)\(^c\)
- Ileal 9.0
- Total tract 13.5
- Ileal DE: total tract DE 0.67

\(a\) NFE (g/kg) = 1000 - moisture g/kg - crude protein g/kg - crude fat g/kg - crude fibre g/kg – ash g/kg.

\(b\) 3-(-N-oxylyl)-L-2,3-diaminopropionic acid.

\(c\) Determined with 43-kg pigs (n=6) fitted with a simple T-piece cannula.
Table 2. Composition, apparent ileal digestibility, apparent and standardised ileal digestible content of amino acids (air-dry basis) in *Lathyrus cicera* cv Chalus fed to 43-kg growing pigs

<table>
<thead>
<tr>
<th>Composition</th>
<th>AID&lt;sup&gt;a&lt;/sup&gt;</th>
<th>AID AA&lt;sup&gt;c&lt;/sup&gt;</th>
<th>SID AA&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/kg</td>
<td>g/16g N</td>
<td>% (±SEM)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Indispensable amino acid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arginine</td>
<td>21.6</td>
<td>8.15</td>
<td>87.1 (1.19)</td>
</tr>
<tr>
<td>Histidine</td>
<td>5.5</td>
<td>2.08</td>
<td>71.4 (2.00)</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>9.0</td>
<td>3.40</td>
<td>75.7 (1.80)</td>
</tr>
<tr>
<td>Leucine</td>
<td>16.8</td>
<td>6.34</td>
<td>68.9 (1.78)</td>
</tr>
<tr>
<td>Lysine</td>
<td>16.2</td>
<td>6.11</td>
<td>79.5 (1.49)</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.0</td>
<td>0.75</td>
<td>69.3 (3.25)</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>9.9</td>
<td>3.74</td>
<td>71.5 (1.60)</td>
</tr>
<tr>
<td>Threonine</td>
<td>8.6</td>
<td>3.25</td>
<td>62.4 (2.74)</td>
</tr>
<tr>
<td>Valine</td>
<td>9.9</td>
<td>3.74</td>
<td>67.6 (2.38)</td>
</tr>
<tr>
<td>Dispensable amino acid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alanine</td>
<td>9.0</td>
<td>3.40</td>
<td>55.9 (3.00)</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>23.6</td>
<td>8.91</td>
<td>68.9 (2.10)</td>
</tr>
<tr>
<td>Cystine</td>
<td>2.4</td>
<td>0.91</td>
<td>52.5 (3.06)</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>40.4</td>
<td>15.25</td>
<td>72.8 (1.16)</td>
</tr>
<tr>
<td>Glycine</td>
<td>10.0</td>
<td>3.77</td>
<td>56.6 (4.14)</td>
</tr>
<tr>
<td>Proline</td>
<td>10.0</td>
<td>3.77</td>
<td>68.7 (4.63)</td>
</tr>
<tr>
<td>Serine</td>
<td>12.0</td>
<td>4.53</td>
<td>58.5 (2.06)</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>7.4</td>
<td>2.79</td>
<td>73.4 (1.78)</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>42.4</td>
<td>68.4 (4.50)</td>
<td>29.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>AID: apparent ileal digestibility.

<sup>b</sup>Standard error of mean where *n*=6.

<sup>c</sup>AID AA: apparent ileal digestible amino acids.

<sup>d</sup>SID AA: standardised ileal digestible amino acids, calculated using endogenous amino acid losses determined in 34-kg growing pigs under a protein-free method (Stein et al., 1999).