**Grain Legumes for Animal Feeds**

**Key Points**
- This Arable Update introduces the Grain Legumes project which several subsequent Arable Updates have developed from.
- NZ grown grain legumes are under increasing demand from the animal feed sector and growers need to understand what the feed industry needs and that grain quality is a variable and complex issue.
- It is clear from the research done in this project that NZ grown peas, faba beans and white lupins have great potential for use in pig and poultry feeds.

**Introduction**

New Zealand does not have BSE (mad cow disease) yet we must prove to the international market place that we are doing everything possible to minimise risk of exposure to BSE. Meat and bone meal (MBM) is manufactured mainly from ruminant animals and is an important protein constituent of animal feeds.

MBM can no longer be used in mills that produce ruminant animal feeds. This has caused difficulties for manufacturers as monogastric (pigs and poultry) feeds are the largest component of the NZ feed industry. Thus there are concerns about the options for other proteins (>60,000t/year MBM was previously used).

Around 78,000t per year of imported soybean meal is used as a protein source in monogastric feeds in NZ but concerns over international pricing and sourcing GM-free material led the NZ Feed Manufacturers Association & FAR to investigate locally grown grain legume alternatives. Peas have been widely grown in NZ for many years, but we needed to also look at other grain legumes with potentially higher quality. A locally grown product would give the industry more stability and confidence while a choice of legumes would also give added flexibility in diet formulations.

The project activities were:
- A literature review to identify protein crops grown internationally, legumes grown previously in NZ and the agronomic and nutritional issues for each crop.
- Determine which crops could be grown successfully in NZ and how optimum yields and quality could be achieved.
- Evaluate the nutritional components and limitations of each legume.

The programme was part funded by MAF’s Sustainable Farming Fund (SFF) over 4 years.

**Nutritional Composition**

MBM contains 50-60% protein, but is quite variable (more so than plant proteins), depending on the meat works, animals processed and blood and offal content.

Processing temperatures are important also – too low and risks of salmonella and other microbes increase; too high and nutrient availability is reduced.

The main concern in evaluating grain legumes was the effect of any anti-nutritional factors (ANF). An ANF can be any of several toxins which could harm the animal, and major ones for monogastric animals are protease inhibitors, lectins, tannins, alkaloids, saponins and mycotoxins. The level of inclusion of a feed component may be limited by the need to keep ANFs low, rather than by nutritional balance.

Soybeans contain high levels of ANF (trypsin inhibitors). For use in animal feeds, soybeans must be heat treated to remove 90% of the ANF activity, which is the best compromise between product safety and lysine availability. Soybean meal has been heat treated during the extraction of soybean oil and the meal by-product is used in animal feeds. White peas are better suited to animal feeds than the coloured types. Some blue peas have high levels of trypsin inhibitors while darker seed coats contain tannins.

Another issue is non-starch polysaccharides (NSP) as these are not broken down for digestion in the gut of the monogastric animal. The use of enzymes, pelleting or extrusion all help breakdown NSPs and minimise this issue.

The characteristics of each grain legume species can be summarised from international literature as follows:
- **Soybeans** - Protein 40-50%, high lysine, low methionine.
Peas - Protein 20-30%, good amino acid (aa) availability, but low in sulphur-containing aa; high utilisation of energy by monogastrics.
Lupins - Protein 30-45%, main type being sulphur deficient globulin, highly digestible; low in lysine and

Animal Requirements

There are numerous reports from several countries on inclusion rates of grain legumes in animal feeds. Currently it is generally accepted that because of ANF and NSP, peas, lupins and faba beans should not be relied on as the only protein source, ie they should be included at limited levels to reduce the use of MBM or soybean meal.

Peas are currently included in pig and poultry diets at higher levels than fabas and lupins. In Europe, 25-30% inclusion in pig diets is suggested, with up to 40% in Australia. Up to 30% of broiler chicken diets can be peas, although poultry are not able to utilise pea starch and fibre well.

Pigs are sensitive to bitter tastes from low levels of alkaloids in lupins so, in general, lupins are better suited to poultry than pig feeds. In Europe lupins have been used at up to 10% inclusion rates for baconer pigs. For poultry, 5-30% for broiler hens and 7-10% for layer hens appear common levels.

Faba beans are widely used in animal feeds. For example, recommendations in Germany for tannin-containing faba beans for inclusion into pig and poultry diets are as follows:

<table>
<thead>
<tr>
<th></th>
<th>sows: 5-15 %</th>
<th>piglets (&gt;15 kg): 5 %</th>
<th>grower pigs: 5-15 %</th>
<th>bacon pigs: 15-25 %</th>
<th>broiler hens: 20-40 %</th>
<th>laying hens: 5-10 %</th>
</tr>
</thead>
</table>

Any serious recommendations for tannin-free beans are not available in Europe yet as this raw material has only been available on the market a short time. But a recent Canadian report stated that zero tannin beans can be included in grower pig diets at up to 30%.

Year 1

The biggest challenge in the 2003/04 season was to find seed. We found 2 species of lupins (sweet and white lupins), 4 Kabuli chickpeas and 2 soybeans and these were compared with a range of pea cultivars. As the first trials weren’t being sown until October, we didn’t search for faba beans. Trials were sown in Ashburton, Chertsey, Marton and Pupekohe.

Some of the lupins did not set enough seed to warrant harvesting (they needed to be sown earlier) but the top yields were close to pea yields, which ranged from 0.8 to 4.1 t/ha. Soybeans were only sown at the North Island sites. The chickpeas did not produce more than 1 t/ha at any site, so were dropped from future trials.

There were no major differences in chemical analysis (protein, fat, fibre, etc) between cultivars or sites but there were large differences between species, with soybeans having the best chemical analysis, followed by lupins. Soybean and lupin protein levels were similar but white lupins had high manganese yet also high energy.

Year 2

Faba beans from 3 different sources (although not necessarily different cultivars), a larger seeded broad bean, 4 pea cultivars, 3 sweet lupins and 3 white lupins (2 cultivars of each lupin were obtained from Australia) were evaluated. A range of diets using this grain and an imported soybean meal (SBM) were fed to chickens in a trial from day 28 to 35. Sampling was then done to determine the apparent metabolisable energy (AME) and apparent ileal digestibility of essential amino acids (AIL) for each legume.

<table>
<thead>
<tr>
<th></th>
<th>Faba</th>
<th>S. Lupin</th>
<th>W. Lupin</th>
<th>Peas</th>
<th>SBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>protein</td>
<td>24.9</td>
<td>26.2</td>
<td>31.4</td>
<td>20.3</td>
<td>46.9</td>
</tr>
<tr>
<td>fat</td>
<td>1.9</td>
<td>6.0</td>
<td>11.2</td>
<td>1.9</td>
<td>6.0</td>
</tr>
<tr>
<td>AME</td>
<td>10.2</td>
<td>6.8</td>
<td>9.1</td>
<td>10.3</td>
<td>11.1</td>
</tr>
<tr>
<td>AIL</td>
<td>0.80</td>
<td>0.84</td>
<td>0.87</td>
<td>0.83</td>
<td>0.85</td>
</tr>
</tbody>
</table>

The cost of establishing a plant for heat treatment of locally produced soybeans was prohibitive so for the following year the focus in the project remained on peas, faba beans and white lupins.

Year 3

Field trials continued to evaluate agronomic issues of grain legumes. There were two nutritional evaluations - a full scale feeding trial plus a small evaluation of the effect of grain dehulling. The large trial compared diets including peas, faba beans or white lupins at up to 20% inclusion levels against wheat-soybean based diets all with or without MBM (proportion of soybean meal was increased in the nil MBM diets).

There was very little difference in bird performance for the different feeds (Tables 2 & 3) irrespective of MBM or which grain legume was included.

<table>
<thead>
<tr>
<th></th>
<th>1-35 days</th>
<th>Soybean</th>
<th>Fabas</th>
<th>Lupin</th>
<th>Peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight gain, g/bird</td>
<td>2438</td>
<td>2431</td>
<td>2495</td>
<td>2369</td>
<td></td>
</tr>
<tr>
<td>Feed intake, g/bird</td>
<td>3737</td>
<td>3709</td>
<td>3804</td>
<td>3694</td>
<td></td>
</tr>
<tr>
<td>Feed per gain, g/g</td>
<td>1.54</td>
<td>1.54</td>
<td>1.56</td>
<td>1.56</td>
<td></td>
</tr>
</tbody>
</table>

In the dehulling trial, it was shown that the amino acid concentrations in all 3 legumes were increased in the dehulled meals compared to the whole legume meal. However, removal of the hull had no effect on the AIL. The AME values of faba beans and white lupins were improved by dehulling, but not of the peas. Overall, dehulling of grain legumes is likely to be nutritionally beneficial and economical in view of the improved amino acid concentrations and energy values.

Acknowledgements

Quality testing was done by Professor Ravindran and his team at Massey University. The project is managed by Jacqui Johnstone, who prepared this Update.

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