Using Pulses, Canola Meal and Other Strategies to Enhance the Cost-Competitiveness of Swine Diets and Resulting Production Efficiency

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▪ Introduction

Optimising feed costs and implementing strategies to improve efficiency is essential if modern pork production is to remain profitable. A wide range of external factors currently challenge the viability of pig enterprises worldwide, including foreign exchange rates, consumption of limited starch and edible oil resources for ethanol and bio-diesel production and competing pork import and export markets.

Pulses and oilseed meals have represented a valuable nutrient source for pigs for many years, but their importance in pig diets may be increasing. Firstly, they have potential to supply significant proportions of energy as well as protein without being in demand for biofuel production or in fact increasing in availability as a result of biofuel production. Secondly, increasing scrutiny over the use of mammalian proteins in pig diets and segregation within feed mills means pulses and oilseed meals are sometimes the only protein sources available. This paper describes opportunities to exploit pulses and canola meal in pig diets and ways to ensure the nutrients they supply are used with optimum efficiency.

▪ Nutritional Attributes of Pulses and Canola Meal

Pulses

Field peas, lupins and faba beans are the dominant pulses utilised as nutrient sources for pigs, but other pulses such as mung beans, chick peas, cow peas, lentils, dried culinary beans and adzuki beans (and associated offals from splitting or seed cleaning) are sometimes offered to feed manufacturers as screenings or material failing to meet export standards for human food markets. Field peas are often portrayed as the “benchmark” pulse for pigs due to their generous supply of protein and starch-derived energy compared with lupins that have little or no starch. A comparison of the nutritional quality of field peas, lupins and faba beans (**Table 1**) shows that field peas contribute more available lysine than other pulses to pig diets and comparable levels of digestible energy.

The comparatively high crude protein and available amino acid content of pulses compared with cereals makes them a valuable addition to pig diets. In contrast, the lower starch content of peas, and particularly lupins, compared with cereal grains, reduces their net energy contributions to pig diets (i.e. a higher proportion of the energy derived from pulses fed to pigs is derived from fermentation in the hind gut compared to cereals) and this needs to be considered if they are being incorporated into diets at higher than traditional levels. The comparatively low sulphur amino acid and tryptophan content of pulses must be noted (less of an issue in field peas and beans than in lupins), but it is of little consequence when formulating pig diets because this deficiency can be made up from other feed ingredients or the addition of synthetic amino acids to the diet at minimal cost.

Table 1. Nutritional value of pulses used in pig diets (as fed)
(van Barneveld, 2003).

Pulse	Available lysine (g/kg)	Digestible Energy (MJ/kg)
Pisum sativum	14.3	14.4
Lupinus angustifolius	11.4	14.2
Lupinus albus	10.9	15.6
Vicia faba	12.9	14.5

Canola Meal

The response of pigs of all ages to canola meal inclusion in diets is generally favourable, although many reviews completed to date list qualifications. In particular, the nutritional quality of canola meal will be influenced by:

- The residual oil content which will impact on the digestible energy content of the meal;
- The levels of glucosinolates and the need to ensure they do not impair circulating tri-iodothyronine levels or feed intake.

- The level of heat imparted during oil extraction does not damage the residual proteins and thus reduce bioavailability of amino acids.

The processing conditions imposed on canola seed during oil extraction will have the greatest impact on the above factors. The digestible energy content of the canola meal is directly related to the level of residual oil. The higher the oil content, the higher the DE content. Hind-gut fermentation plays a limited role in the derivation of energy from canola meal in wheat based diets. Ratios between ileal and faecal DE values for cold-pressed, expeller and solvent-extracted canola meal samples have been shown to be 0.96, 0.89 and 0.86, respectively, with these results simply reflecting the differing sources of digestible energy from the canola meal samples (van Barneveld*,* 1998). As cold-pressed canola meal has higher oil content, and a higher proportion of the energy is digested in the small intestine, compared with solvent-extracted canola meal.

Table 2. Comparison of lysine forms in cold-pressed (CP), expeller-extracted and solvent-extracted canola meal fed to growing pigs (van Barneveld et al. 1999).

	Canola sample			
Measurement (g/kg DM)	**Seed**	**CP**	**Expeller**	**Solvent**
Total lysine	11.68	17.41	17.25	18.70
Reactive lysine	8.83	13.00	10.88	11.38
Apparent ID lysine	-	14.62	13.20	14.74
True ID lysine	-	16.02	14.49	16.08
Apparent ID reactive lysine	-	11.15	8.53	9.23
True ID reactive lysine	-	12.35	9.79	10.35

ID, ileal digestible

Heat damage during canola meal processing and drying can result in an overestimation of nutritional quality due to reactions between the ε-amino group of lysine with other compounds. Techniques have been developed whereby bound lysine is guanidinated to homoarginine (reactive lysine) as a means of assessing heat damage in feed ingredients. This technique has been applied to assess the degree of heat damage in cold-pressed, expeller extracted and solvent extracted canola meal destined for use in pig diets. Despite similar total lysine concentrations in the canola meals, true ileal reactive lysine digestibility is significantly higher in meals subjected to lower processing temperatures (**Table 2**) (van Barneveld *et al.* 1999). Gross reactive lysine content is a good indicator of true ileal digestible reactive lysine content (and thus the degree of heat damage). This technique may have a role in the routine assessment of canola meal quality and the quality of other ingredients that are routinely subjected to, or derived from, heat imparting processing methods (van Barneveld, 2001). Variation in the reactive lysine content of canola meal samples within and between processing facilities has recently been further investigated by Spragg and Mailer (2007) to reveal a significant degree of variation and a need to account for this variation prior to diet formulations.

▪ Maximum Inclusion Levels of Pulses and Canola Meal

With increasing cost pressure against the cereal component of pig diets, there is potential to increase the use of pulses and canola meal as energy sources as well as protein sources. As a consequence, there is a need to review the factors that influence maximum inclusion level of these ingredients so they can be used as constraints when formulating commercial diets.

Pulses

A range of chemical constituents within pulses can influence their inclusion level and the utilization of other ingredients in pig diets. While many breeding programs have focused on reduction in key anti-nutritional factors (ANFs) it is worthwhile revisiting upper constraints in pig diets, if opportunities exist to secure high yielding varieties with elevated ANF levels. Oligosaccharide and non-starch polysaccharide characteristics of pulses can also influence their use in pig diets. Key considerations include:

Oligosaccharides:

Ethanol extraction to remove oligosaccharides from lupins has been shown to increase digestible energy content by up to 0.7 MJ/kg depending on variety and improve the ileal digestion of all amino acids by more than 9% (van Barneveld et al. 1996)

Non-starch polysaccharides:

Growing pigs fitted with ileal cannulas and fed diets containing graded levels of a lupin NSP isolate experience a significant linear decrease in lysine and energy digestibility (van Barneveld *et al.* 1995a,b). The source of NSP can also influence the response of pigs to pulses in diets. For example, diets formulated to contain equal levels of digestible energy and ileal digestible amino acids do not necessarily result in equivalent pig performance levels depending on the cereal and pulse combination. Pigs fed combinations of chick peas (35%) and wheat, barley, sorghum or triticale, respectively (50%), exhibited no significant differences in their empty-body weight gains. In contrast, a highly significant difference was observed in the empty-body-weight gain of pigs fed a diet containing lupins and barley compared to lupins and wheat and lupins and triticale, respectively (**Table 3**). This suggests that apparent lysine digestibility and digestible energy values are not additive when lupins are combined with cereals at high levels in a mixed diet.

Table 3. Measured and calculated apparent ileal digestible lysine coefficients in mixed diets containing lupins and cereals fed to growing pigs (van Barneveld et al. 1997a).

	Measured IDL	Calculated IDL	Difference	
Lupins + wheat	0.86	0.87	0.0019	NS
Lupins + barley	0.79	0.83	0.0353	*
Lupins + triticale	0.91	0.88	-0.0311	NS
Lupins + sorghum	0.84	0.85	0.0131	NS

IDL, Ileal digestible lysine; NS, not significant; *, $P<0.05$

Anti-nutritional Factors:

Protease inhibitors, trypsin inhibitors, lectins and tannins are the most important ANF's from an animal nutrition perspective in pulses. Trypsin inhibitors and lectins are mainly present in peas, lentils and beans. Tannins can be relevant in faba beans and some pea varieties. Other ANF's which can be relevant are vicine and co-vicine in faba beans and alkaloids in lupins. Less important ANF's in grain legumes are α-amylase inhibitors, saponins and phytates.

Trypsin inhibitors:

Trypsin inhibitor activity (TIA) exceeding 2.5 can reduce the apparent ileal digestibility of protein. Modern breeds of high quality peas contain a TIA level of between 1 and 2, yet it is not uncommon for some widely used varieties to have TIA levels of 3 to 4 with some reaching 8 to 11 (van Barneveld et al. 1997b).

Lectins:

Lectins are predominantly important in Phaseolus Beans, because they are exceptionally toxic and can decrease apparent amino acid digestibility considerably through increases in the excretion of endogenous protein. In contrast, pea lectins have been reported to be non-toxic in piglets (van Barneveld et al. 1997b).

Tannins:

Tannins are present in the coloured seeds of faba beans and other pulses. Tannins complex with proteins easily, but binding with other nutrients (carbohydrates, minerals) can also take place. Condensed tannins increase the excretion of endogenous and exogenous protein (van Barneveld et al. 1997b).

Canola Meal

The primary factor influencing the inclusion of canola meal in pig diets is the glucosinolate content. Based on low glucosinolate (less than 5µmole/g), in solvent extracted canola meal, the following inclusion rates can be utilized for pig diets:

- Weaner pigs can tolerate up to 250 g/kg canola meal in diets from weaning at 20 days of age to 62 days of age without adversely affecting growth performance (King, 2000).
- Canola meal can be included in grower/finisher diets up to 300 g/kg without any adverse effect on growth performance or thyroid function (King, 2000)
- Up to 200 g/kg canola meal can be included in diets for lactating sows without reducing their lactation or reproductive performance (King, 2000).

▪ Accounting for Variation in Pulse and Canola Meal Quality

Pulses

It is important to note that while there may be varietal differences and influences from agronomic and/or environmental practices on the nutritional quality of pulses, all sources will have some value as a stockfeed providing this value can be ascertained prior to feeding. This also means that yield is one of the most important plant breeding and agronomic objectives if the net value of pulses to the grain grower is to be increased. Grain growers and plant breeders need to recognize that livestock feeding is a very competitive business and business advantage usually vests with a capacity to procure ingredients for the lowest possible cost and then utilise these ingredients as efficiently as possible. With the exception of removal of anti-nutritional factors (unless it compromises yield), recommendations from the livestock sector for breeding will generally be focused on increasing yield and the development of dedicated feed grain supplies in regions close to pig production.

Variation in the nutritional quality of pulses is usually accounted for through the assessment of crude protein content only. However, if use rates in pig diets increase, with a subsequent increase in the supply of dietary energy from pulses, further assessment to account for variation in digestible energy content may also be required (**Table 4**). Given the high proportion of energy derived from non-starch polysaccharides in some pulses, consideration of net energy supply may also be required.

Table 4. Variation in the digestible energy (DE) content for pigs of lupins and field peas (van Barneveld, 2003).

Pulse	Pig DE (MJ/kg DM)
Lupins (*L.angustifolius* cv gungurru)	13.6-17.0
Field peas	14.2-17.1

Canola Meal

Assessment of canola meal quality can be achieved through measurements of crude protein content and crude fat content (which are well correlated with amino acid levels and digestible energy content, respectively), and total reactive lysine content as a measure of heat damage and the proportion of digestible lysine. All of these measurements can be completed using near infra-red spectrophotometry (NIRS).

To assess the potential for NIRS to measure total and reactive lysine in canola meal, van Barneveld (2001) subjected samples to a structured range of dry and autoclaved heat treatments combined with collected samples of commercially processed canola meal to develop sample set. NIRS calibrations were then developed for both total and reactive lysine with a high level of accuracy (**Table 5**). These calibrations are now being assessed and refined for commercial use during canola processing and drying and prior to incorporation into pig diets (Spragg and Mailer, 2007).

Table 5. Performance indicators for NIRS calibrations developed for the prediction of total and reactive lysine (g/kg, as received) in cold-pressed and solvent-extracted canola meal samples (van Barneveld, 2001).

Constituent	SEL	SECV	SD	SECV/SEL	SECV/SD
Total lysine	0.40	0.42	4.64	1: 1.05	0.09
Reactive lysine	0.60	0.76	4.46	1: 1.27	0.17

SEL, Standard error of laboratory reference; SECV, Standard error of cross validation; SD, Standard deviation.

Conclusions

Pulses and oilseed meals will be in increased demand for use in pig diets given the cost pressures against cereals and increasing scrutiny over the inclusion of mammalian proteins in livestock diets. There is sufficient nutritional knowledge to ensure pulses and canola meal are included in pig diets and utilized with optimum efficiency, however, there is a need to ensure variation in nutritional quality is accounted for prior to diet formulation and to ensure that higher inclusion levels of these products are not comprised as a result of lack of attention to the potential negative effects of anti-nutritional factors or non-starch polysaccharides.

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