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Performance and intestinal responses to dehulling and inclusion level of Australian sweet lupins (*Lupinus angustifolius* L.) in diets for weaner pigs

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ABSTRACT

A total of 180 entire male weaner pigs weighing 6.4 ± 0.1 kg (mean ± SEM) and housed in pairs was used in a completely randomised block design with 9 dietary treatments (n = 10 pens). Pigs were blocked based on weaning weight. The diets were (i) a wheat-based control diet containing 240 g/kg of milk products (whey and skim milk powder), and (ii) 8 diets containing whole or dehulled lupins (cv. Coromup) that substituted the milk products at 60, 120, 180 and 240 g/kg of diet (replace 25%, 50%, 75%, or 100% of the milk products in the control diets). The diets were isoenergetic [15 MJ digestible energy (DE)/kg], and were formulated to contain the same ileal standardised digestible lysine content (0.85 g/MJ DE) and ideal patterns of other essential amino acids. Pigs receiving 240 g/kg of dehulled lupins grew slower ($P<0.05$) than pigs fed the other diets mainly due to decreased feed intake. Pigs fed diets containing more than 180 g/kg of dehulled lupins had a higher faecal β-haemolytic *Escherichia coli* score on day 3 after weaning ($P<0.05$). Moreover, inclusion of 240 g/kg of whole lupin or more than 180 g/kg of dehulled lupins increased ($P<0.001$) plasma urea nitrogen (PUN) levels. Total tract apparent digestibility (TTAD) of dry matter decreased ($P<0.001$) in all lupin diets compared with the control diet. These data indicate that inclusion of dehulled lupin immediately after weaning should be limited to less than 180 g/kg whilst whole lupins can be included up to 240 g/kg without deleterious effects on production and intestinal health.

1. Introduction

Traditionally, high quality piglet feeds have been based on using relatively high percentages of lactose, fat and (or) cooked cereals such as oats as energy sources, and a combination of whey powder, high quality fishmeal and dried skim milk as sources of protein. However the cost of many of these ingredients has increased dramatically in recent times and there are certainly indications that their availability will continue to be variable.

Australian sweet lupins (*Lupinus angustifolius* L.; ASL) are less expensive than most other sources of protein available for feeding weaner pigs. Recent research in grower pigs demonstrated that ASL can be included at up to 350 g/kg in replacement

Abbreviations: AA, amino acid(s); ADF, acid detergent fibre; ASL, Australian sweet lupins; DM, dry matter; FCR, feed conversion ration; GIT, gastrointestinal tract; NDF, neutral detergent fibre; NSP, non-starch polysaccharides; PUN, plasma urea nitrogen; PWD, post-weaning diarrhoea; TTAD, total-tract apparent digestibility.

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of soybean meal without compromising growth, carcass composition and meat quality (Kim et al., 2011). However, the use of higher levels of lupins in a weaner diet to reduce or replace the more expensive protein sources, such as fishmeal and milk products, has not been examined to date. Lupins contain about 250 g/kg of seed coat (hull), which is mostly insoluble fibre, and its kernel contains about 300 g/kg of cell wall materials called polygalacturonans (Kim et al., 2007). Therefore, use of lupins in commercial weaner diets has been limited to 50–100 g/kg on the basis that pigs would have limited ability to deal with the high fibre content of whole lupins. In a previous study, however, we showed that yellow lupin seeds could be included at up to 150 g/kg in weaner diets without compromising performance of pigs (Kim et al., 2008a). In this regard, it is possible that a similar or greater amount of ASL seeds could be used in a weaner diet. Moreover, there is general perception that removal of the hull, which is indigestible, from lupins may offer the opportunity for even higher inclusion levels (*i.e.* >150 g/kg) as increased amounts of insoluble fibre may physically limit the quantity of lupins that can be incorporated in a diet for weaner pigs.

The change in diet from sows' milk to solid feed at weaning disrupts the structure and function of the gastro-intestinal tract (GIT). Post-weaning diarrhoea (PWD) is often a consequence of this malaise. In this regard, the role of dietary fibre in the post-weaning period has been studied, with the source, type, structure and absolute amount of fibre in the diet all known to have effects on the structure and function of the GIT (*e.g.*, Pluske et al., 2002; De Lange et al., 2010). Previous research by Kim et al. (2008b) showed that a small amount of insoluble fibre, as oat hulls, was beneficial for prevention of PWD, whilst soluble fibres are seemingly associated with proliferation of certain enteric pathogens (*e.g.*, Pluske et al., 1996; Hopwood et al., 2004). As ASL contain two distinctive fibre sources in the hull (insoluble fibre, mostly cellulose and xylose) and kernel (some pectin-like soluble fibres and largely fermentable fibres, polygalactouronans), increasing amounts of these fibres in diets for weaner pigs may promote or compromise GIT structure and function. No such experiments to measure the impact of lupin inclusion level on digestibility and indices of GIT function have been conducted, to our knowledge.

Therefore, the purpose of this study was to examine performance and intestinal responses to whole and dehulled ASL as alternatives to more expensive animal protein sources. The hypotheses tested in this experiment were: (1) performance of weaner pigs will decline as the inclusion level of whole and dehulled lupins increases in the diet; (2) weaner pigs fed dehulled lupins will perform better than pigs fed whole lupins at the same rate; and (3) indices of GIT function such as faecal consistency and β-haemolytic *Escherichia coli* score will be compromised when pigs are fed more than 180 g/kg whole or dehulled lupins.

2. Materials and methods

The experimental protocol used in this study was approved by the Department of Agriculture and Food Western Australia Animal Ethics Committee (AEC 6-08-41). Animals were handled according to the Australian code of practice for the care and use of animals for scientific purposes (NHMRC, 2004).

2.1. Lupins, diets, animals, and experimental design

A high protein ASL, cv. Coromup, was selected for the study because it is the variety most likely to be grown in the future in Western Australia (WA). In turn, WA produces approximately 80% of the world's angustifolius lupins (FAOSTAT, 2008). The lupin was collected from the northern agricultural region of WA (Geraldton, WA) which has a reasonably generic soil type (sand over loam). The lupin contained 319 g protein, 346 g insoluble non-starch polysaccharides (NSP) and 24 g soluble NSP (Kim et al., 2009a).

A total of 180 entire male pigs weaned at 21 days of age and weighing 6.4 ± 0.1 kg (mean ± SEM) was acquired from a high health status commercial farm and be transported to the Medina Research Station. Two replicate studies using 90 pigs per replicate were conducted, with an interval of a month between each. Upon arrival, pigs were weighed, ear tagged, housed as pairs (space allowance 0.4 m^2 per pig) and were allocated to 9 dietary treatments based on weaning weight.

The experiment was a completely randomised block design with 9 dietary treatments, as follows: (i) a wheat-based control diet containing 240 g/kg of whey and skim milk powder, and (ii) 8 diets containing whole or dehulled lupins (cv. Coromup) that substituted the milk products at 60, 120, 180 and 240 g/kg of diet (replace 25%, 50%, 75%, or 100% of the milk products in the control diets). The whole and dehulled lupins were hammermilled to a mean particle size of 700 μm and directly dumped into the mixer. Digestible energy and ileal digestible indispensable AA contents were equalised using soy protein concentrate, canola oil, full fat soya and meat meal. The diets were isoenergetic (15 MJ DE/kg), and were formulated to contain the same ileal standardised digestible lysine content (Sauvant et al., 2004, 0.85 g/MJ DE) and ideal patterns of other indispensable AA. Composition and chemical contents of diets are presented in Table 1. All diets contained 2 g/kg titanium dioxide as a digestibility marker (Short et al., 1996) to estimate the total tract apparent digestibility (TTAD) of dry matter (DM). Nutrient composition of dehulled lupins used in this study was not chemically determined. Tabulated values (Table 2) reported in the previous publication (Kim et al., 2007) were used for diet formulation, as nutrient composition of lupin kernels shows a low variation.

2.2. Experimental procedure and measurements

Pigs were fed their respective diets as a mash form and on an *ad libitum* basis for 3 weeks. Fresh water was available throughout the experiment. Pigs were weighed weekly and feed intake was measured on a daily basis. Pigs having diarrhoea