The Effect of Different Lupin Kernel Inclusion Levels on the Growth and Carcass Composition of Growing and Finishing Pigs

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ABSTRACT : Two experiments were conducted to investigate the effect of different lupin kernel levels on growth performance and carcass characteristics of growing and finishing pigs. In experiment 1, a total of 54 barrows and 54 growing gilts, with an average initial body weight of 24.7±0.38 kg, was used to determine the effect of different lupin kernel levels (0, 10% and 20%; Control, LK10 and LK20, respectively) in the diets on growth performance with a 3×3 randomized complete block design for 35 days. There were no significant differences in average daily gain (ADG), average daily feed intake (ADFI) and feed:gain among treatments. In experiment 2, a total of 54 barrows and 36 finishing gilts, with an average initial body weight of 63.0±0.56 kg, was used to determine the effect of different lupin kernel levels (0, 15% and 30%; Control, LK15 and LK30, respectively) in the diets on growth performance and carcass characteristics with a 3×3 randomized complete block design for 63 days. LK30 decreased ADG and ADFI compared with the Control and LK15 ($p<0.05$). However, LK30 tended to improve feed:gain compared with the Control and LK15. And LK15 did not differ from the Control in ADG, ADFI and feed:gain. With inclusion of lupin kernel in the finishing diet, backfat thickness increased ($p<0.01$) and carcass grade tended to be improved compared with the Control. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 2 : 207-212*)

Key Words : Lupin Kernel, Growth, Carcass, Pigs

INTRODUCTION

Lupins have been cultivated as a grain crop for over 3,000 years, primarily in the Mediterranean, parts of the Middle East and in South America. However, in the past, the extreme bitterness of the seed has generally made lupins unsuitable for human or animal consumption without prior treatment to remove toxic alkaloids (King, 1990).

The type of lupins being produced today for export markets bears little resemblance to its predecessors. After extensive non-GMO plant breeding efforts, the composition of the present day varieties is far superior to those grown originally. Around one million tonnes of the sweet (i.e., low-alkaloid) lupins, *Lupinus angustifolius*, are traded on world markets annually with approximately 85% originating from the State of Western Australia. Today in Western Australia, around 38,000 tonnes of lupin seed are fed to pigs each year (Godfrey, 1998). However, it has been estimated that 350,000 tonnes could be used in Australian pig diets if not for the regions of lupin production being well beyond the boundaries of economic transportation to major swine growing centres (van Barneveld et al., 1996).

Conversely, most of the lupins produced in Europe are varieties from the cultivars *Lupinus albus*, which is poorly tolerated by pigs, even at low inclusion levels (King, 1981; Batterham et al., 1986; Edwards and van Barneveld, 1998).

The objectives of these experiments were to evaluate the effect of inclusion levels of Western Australian sweet lupin kernel (*L. angustifolius*) on growth performance and carcass characteristics of growing and finishing pigs.

MATERIALS AND METHODS

Experimental design and animal management

In experiment 1, a total of fifty four barrows and fifty four gilts (Landrace×Large White×Duroc), with an average initial body weight of 24.7±0.38 kg, was grouped by initial body weight and sex in a 3×3 randomized complete block design for 35 days from July 14, 1998 to August 18, 1998 at the experimental farm of TS Corporation in Korea. Animals were divided into nine pens with six barrows and six gilts per pen, and assigned three pens per treatment. Animals were housed in a finishing barn with mechanical ventilation. Each pen had totally slotted floors and contained a single hole semi-wet feeder to allow *ad libitum* consumption of feed and water. Animals were weighed at initiation and conclusion, and feed intake was checked every week to calculate ADG, ADFI and feed:gain.

In experiment 2, a total of fifty four barrows and thirty six gilts (Landrace×Large White×Duroc), with an average initial body weight of 63.0±0.56 kg, was grouped by initial body weight and sex in a 3×3 randomized complete block design for 63 days from July 14, 1998 to September 15, 1998 at the experimental farm of TS Corporation in Korea.

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Animals were divided into nine pens with six barrows and four gilts per pen, and assigned three pens per treatment. The animals were housed in a finishing barn with mechanical ventilation. Each pen contained a single hole semi-wet feeder to allow *ad libitum* consumption of feed and water. Animals were weighed at initiation, thirty five days after initiation and conclusion, and feed intake was checked every week to calculate ADG, ADFI and feed:gain.

Feed

The seed of *L. angustifolius* (Australian sweet lupin) was dehulled to prepare lupin kernel using a commercial dehulling process. The yield of lupin kernel was approximately 70% of the whole lupin seed. The chemical composition and digestion coefficients of lupin kernel used in these experiments are shown in table 1.

Table 1. Chemical composition and digestion coefficients of lupin kernel used in experimental diets (as-fed basis)

Items	%
Chemical Composition	
Moisture	9.64
Crude protein	37.84
Crude fat	5.40
Crude fiber	7.17
Crude ash	2.96
Calcium	0.13
Total phosphorus	0.31
Lysine	1.82
Methionine	0.29
Cystine	0.58
Threonine	1.36
Isoleucine	1.62
Tryptophan	0.33
Valine	1.50
Histidine	0.90
Arginine	4.00
Phenylalanine	1.50
Leucine	2.30
Alkaloid	0.002
Digestion coefficients[1]	
Protein	90.00
Fat	60.00
Fiber	70.00
Nitrogen free extract	89.20
Phosphorus	45.00

[1] Originated from CVB (1998).

In experiment 1, three experimental diets were designed in a meal form to meet or exceed NRC (1998) requirements using 0, 10% and 20% of lupin kernel (Control, LK10 and LK20, respectively) in the growing diets.

In experiment 2, three experimental diets were designed in a meal form to meet or exceed NRC (1998) requirements using 0, 15% and 30% of lupin kernel (Control, LK15 and LK30, respectively) in the finishing diets.

Experimental diets were fed with semi-wet feeders on an *ad libitum* basis. The formulations and chemical composition of growing and finishing diets are shown in tables 2 and 3, respectively. The chemical composition of lupin kernel and experimental diets were analyzed using AOAC (1990) procedure. And the digestion coefficients of lupin kernel were originated from CVB (1998).

Table 2. Ingredient and chemical composition of experimental diet for growing pigs

Items	Treatment[1]		
	Control	LK10	LK20
Ingredient composition (%)			
Corn	30.00	30.00	30.00
Wheat	31.21	33.42	30.00
Lupin kernel	-	10.00	20.00
Copra meal	5.00	-	-
Soybean meal	24.06	17.44	10.84
Animal fat	2.83	2.12	2.00
Molasses	3.00	3.00	3.00
Liquid lysine-HCl	0.80	0.89	0.94
Lime stone	0.14	0.11	0.16
Tricalcium phosphate	1.68	1.74	1.78
Salt	0.28	0.28	0.28
Vitamin & mineral premix[2]	1.00	1.00	1.00
Chemical composition (%)[3]			
Moisture	12.33	12.31	12.00
Crude protein	18.50	18.50	18.90
Crude fat	4.86	4.58	4.96
Crude fiber	2.97	2.54	2.63
Crude ash	5.10	4.65	4.49
Calcium	0.75	0.75	0.77
Total phosphorus	0.65	0.64	0.62
Available phosphorus	0.40	0.40	0.40
Available lysine	1.00	1.00	1.00
Available methionine	0.25	0.24	0.23
Available Methionine+cystine	0.52	0.52	0.52
Available threonine	0.59	0.58	0.58
Available tryptophan	0.19	0.18	0.18
Net energy (kcal/kg)	2,450	2,450	2,450

[1] Control; No lupin kernel, LK10; 10% of lupin kernel, LK20; 20% of lupin kernel.
[2] Commercial order form designed by TS Corporation.
[3] Calculated values.

Table 3. Ingredient and chemical composition of experimental diet for finishing pigs

Items	Treatment[1]		
	Control	LK15	LK30
Ingredient composition (%)			
Corn	30.00	30.00	33.41
Wheat	37.71	38.16	26.77
Lupin kernel	-	15.00	30.00
Copra meal	4.24	-	-
Soybean meal	18.61	7.88	-
Animal fat	3.00	2.27	2.62
Molasses	3.00	3.00	3.00
Liquid lysine-HCl	0.60	0.78	0.70
Lime stone	0.44	0.41	0.68
Tricalcium phosphate	1.12	1.21	1.26
Salt	0.28	0.29	0.28
Vitamin & mineral premix[2]	1.00	1.00	1.00
Chemical composition (%)[3]			
Moisture	12.37	12.19	11.50
Crude protein	16.50	16.50	17.50
Crude fat	5.02	4.97	6.12
Crude fiber	2.82	2.50	2.64
Crude ash	4.50	3.95	4.29
Calcium	0.65	0.65	0.75
Total phosphorus	0.53	0.50	0.48
Available phosphorus	0.30	0.30	0.30
Available lysine	0.82	0.82	0.82
Available methionine	0.22	0.19	0.16
Available Methionine+cystine	0.48	0.45	0.44
Available threonine	0.51	0.49	0.52
Available tryptophan	0.17	0.15	0.15
Net energy (kcal/kg)	2,500	2,500	2,500

[1] Control; No lupin kernel, LK15; 15% of lupin kernel, LK30; 30% of lupin kernel.
[2] Commercial order form designed by TS Corporation.
[3] Calculated values.

Carcass measurements

In experiment 2, ninety animals averaging 105±0.86 kg of live weight were slaughtered within 3 days of the conclusion of the performance trial at the Dongbu Livestock Products Marketing Center of the National Livestock Cooperatives Federation. Chilled carcass weight was measured after removal of the head, visceral organs and dehairing. Dressing percentage was calculated with chilled carcass weight as a percentage of live weight. Backfat thickness was measured at the area of 10th to 11th and the last rib. Carcass grades were determined according to Korean carcass grading system of the Korea Animal Improvement Association (1998).

Statistical analysis

Statistical analysis was performed by the ANOVA method using GLM procedures of SAS (1985) for a randomized complete block design. ANCOVA was used to test for significant relationships between initial body weight and final body weight as well as between live weight and carcass traits. The effect of lupin kernel inclusion was analyzed by orthogonal contrast to analyze growth performance and carcass traits as compared with the Control.

RESULTS AND DISCUSSION

Experiment 1

Replacement of soybean meal with 10% and 20% of lupin kernel in grower rations had no significant effect on ADG, ADFI and feed:gain (table 4). This result has been widely supported by many literatures.

The maximum level of lupins recommended by the Standing Committee on Agriculture (1987) in Australia is 20 to 25% in grower diets. King (1990) also recommended maximum inclusion levels for *L. angustifolius* of 30% in pig grower and finisher diets. Barnett and Batterham (1981) found that weaner pigs could tolerate up to 43% lupin seed meal (*L. angustifolius)* without adversely effecting growth, while Pearson and Carr (1976) included *L. angustifolius* at levels of up to 37% at the expense of more

Table 4. The effect of lupin kernel inclusion levels on the performance of growing pigs

Items	Treatment[1]			SEM	Contrast[2]
	Control	LK10	LK20		
Initial BW (kg)	24.68	24.70	24.77	0.38	-
Final BW (kg)	51.23	51.34	51.42	0.46	-
ADFI (kg)	1.84	1.89	1.90	0.02	-
ADG (kg)	0.761	0.761	0.764	0.01	-
Feed:gain (kg/kg)	2.42	2.48	2.49	0.05	-

[1] Control; No lupin kernel, LK10; 10% of lupin kernel, LK20; 20% of lupin kernel.
[2] Control vs LK10 and LK20; GLM and orthogonal contrast: - Not significant.

conventional protein concentrates without detrimental effects on the growth of growing pigs. The above references relate specifically to applications of whole-seed lupins and it is expected that lupin kernels would perform at least equally well due to their higher protein and energy levels, together with lower crude fiber content.

In contrast, *L. albus* is not currently recommended to use in pig diets due to the resulting depression of feed intake and growth rates (King, 1981). The maximum recommended inclusion level of *L. albus* is 15% in grower and finisher diets (SCA, 1987; King, 1990).

Experiment 2

Including lupin kernel at 30% (LK30) decreased ADG and ADFI compared with the Control and LK15 ($p<0.05$). However, LK30 tended to improve feed:gain compared with the Control and LK15. There was no significant difference between LK15 and the Control with respect to ADG, ADFI and feed:gain (table 5).

In this experiment, the growth performance of animals across all treatments was relatively below the standard of TS Corporation. It is believed that conditions of high temperature and humidity which prevailed especially during the latter period of the experiment could have decreased growth. During the daytime of this experiment, the room temperature in the finishing barn remained about 30℃ even though mechanical ventilation was operated. Average relative humidity also increased dramatically by 79.4% from August 1 to August 15, 1998 according to daily meteorological data of Korea Meteorological Administration (1998).

The maximum level of whole-seed lupins, *L. angustifolius*, recommended by the Standing Committee on Agriculture (1987) in Australia is 30 to 35% in finisher diets. King (1990) also recommended maximum inclusion levels of *L. angustifolius* of 30% in pig grower and finisher diets. However, the processing of the carbohydrates contained in lupins by hindgut fermentation results in a considerable heat increment which can add to the heat dissipation problem, especially in hot and humid climatic conditions. Under such conditions, and where other fibrous feedstuffs were employed, lupin inclusions might need to be restricted (Edwards, 1997). The results appear to support this, with satisfactory performance when using intermediate levels of lupins (LK15). It is expected that in milder climatic conditions, LK30 would have produced better results in agreement with the published literatures.

It is possible that the effect of adverse environmental conditions could have been exacerbated by synergistic effect of the higher crude protein content of LK30 compared with LK15 and the Control (table 3), which was increased by 1% in order to balance available essential amino acid specifications. De-amination of excess protein would also result in increased heat increment and therefore might have

Table 5. The effect of lupin kernel levels on performance of finishing pigs

Items	Treatment[1]			SEM	Contrast[2]
	Control	LK15	LK30		
	– Jul. 14, 1998 ~ Aug. 18, 1998 (35 days) –				
Initial BW (kg)	62.76	63.28	63.06	0.56	-
Final BW (kg)	87.47[a]	87.06[a]	85.28[b]	0.83	-
ADFI (kg)	2.36[a]	2.31[a]	2.14[b]	0.04	*
ADG (kg)	0.706[a]	0.680[ab]	0.635[b]	0.013	-
Feed:gain (kg/kg)	3.35	3.42	3.37	0.06	-
	– Aug. 18, 1998 ~ Sep. 15, 1998 (28 days) –				
Initial BW (kg)	87.47	87.06	85.28	0.83	-
Final BW (kg)	107.26	106.14	103.65	0.85	-
ADFI (kg)	2.71[a]	2.60[ab]	2.37[b]	0.07	-
ADG (kg)	0.707	0.681	0.656	0.017	-
Feed:gain (kg/kg)	3.84	3.86	3.65	0.13	-
	– Jul. 14, 1998 ~ Sep. 15, 1998 (63 days) –				
Initial BW (kg)	62.76	63.28	63.06	0.55	-
Final BW (kg)	107.26[a]	106.14[a]	103.65[b]	0.86	*
ADFI (kg)	2.52[a]	2.44[a]	2.24[b]	0.05	*
ADG (kg)	0.706[a]	0.680[ab]	0.644[b]	0.094	*
Feed:gain (kg/kg)	3.56	3.59	3.48	0.04	-

[1] Control; No lupin kernel, LK15; 15% of lupin kernel, LK30; 30% of lupin kernel.

[2] Control vs LK15 and LK30; GLM and orthogonal contrast: - Not significant, * $p<0.05$.

[a,b] Means in the same row with different superscripts differ ($p<0.05$).

Table 6. The effect of lupin kernel inclusion levels on carcass characteristics of finishing pigs

Items	Treatment[1]			SEM	Contrast[2]
	Control	LK15	LK30		
Live wt. (kg)	106.7	106.2	103.7	0.85	-
Chilled carcass wt. (kg)	83.9[a]	82.9[a]	79.9[b]	0.66	*
Backfat thickness (mm)	18.6[b]	22.0[a]	21.0[a]	0.55	**
Dressing percentage	78.3[a]	78.1[a]	77.1[b]	0.23	*
Carcass grade (%)[3]					
A	46.7	58.6	56.7		
B	33.3	37.9	36.7		
C	6.7	3.4	3.3		
D	13.3	-	3.3		

[1] Control; No lupin kernel, LK15; 15% of lupin kernel, LK30; 30% of lupin kernel.
[2] Control vs LK15 and LK30; GLM and orthogonal contrast: - Not significant, * $p<0.05$, ** $p<0.01$.
[3] Carcass grade was estimated by Animal Products Grading Service in Korea.
[a,b] Means in the same row with different superscripts differ ($p<0.05$).

contributed to a detrimental effect on growth performance.

Petterson and Mackintosh (1996) summarized some anti-nutritional factors in the genus Lupinus such as alkaloids, allergens, inositol phosphates, lecithins, oligosaccharides, tannins, protease inhibitors and saponins. These authors concluded that, when compared to other grain legumes, modern cultivars of lupins have naturally low contents of anti-nutritional factors and heat treatment is not necessary to improve their feeding value. Historically, alkaloids have been cited as the reason for reduced acceptance of *L. albus* by pigs (Hill and Pastuszewska, 1993) since as the amount of alkaloid in a pig diet increases above 0.03% there is a decrease in feed intake, which in turn reduces live weight gain. However, all lupin varieties currently exported from Australia have very low alkaloid contents that cause no detrimental effects on performance (Edwards, 1997; Iji and Tivey, 1997).

With inclusion of lupin kernel in the finishing diet, backfat thickness increased compared with the Control ($p<0.01$). However, there was no significant difference in backfat thickness between LK15 and LK30 even though the carcass weights of LK30 were lighter than those of LK15. Dressing percentage of pigs fed LK30 was lower than the Control, but LK15 did not differ in dressing percentage with the Control. Carcass grade tended to improve in LK15 and LK30 compared with the Control. It might be due to increased backfat thickness without detrimental effect on dressing percentage (table 6).

Backfat thickness was greater and dressing percentage was higher than normal in this experiment due to the difference in the protocol of the slaughterhouse. In this experiment, carcass weights were measured after removal of the head, visceral organs and dehairing without removal of legs and the skinning process.

The dressing percentage of pigs was reported to decrease by approximately 0.8 (Pearson and Carr, 1976) to 1.4 (King, 1981) percentage units for each 10% increment in dietary levels of lupin seed meal, when whole-seed lupins were given to pigs over the entire grower and finisher phase. King (1981) also reported backfat thickness decreased with inclusion of whole-seed lupin. In this experiment the dressing percentage was not seriously affected even though backfat thickness increased with inclusion of lupin kernel. It is not clear why the carcass traits of this experiment were different from the previous results.

CONCLUSION

It can be concluded that lupin kernel (*L. angustifolius*) can be included at up to 20% in a commercial pig grower diet without any detrimental effects on growth performance. It is also suggested that lupin kernel can be included at 15% in commercial swine finisher diet. Adverse effects on growth performance were observed when 30% of lupin kernel was included in pig finisher diet. It can be suggested that this was mainly due to hot and humid weather conditions, which were exacerbated by the heat increment caused by hindgut fermentation of lupins and possibly the excess nitrogen level of the experimental diet. Carcass grade tended to be improved with inclusion of lupin kernel. It might be due to increased backfat thickness without detrimental effect on dressing percentage. In this experiment, the maximum inclusion level of lupin kernel under high temperature and humidity conditions and its effect on carcass traits in finishing pigs were not clear and should be elucidated in the future. Furthermore, the effect of enzyme supplementation with lupin containing diets should be investigated to reduce anti-nutritional factors such as non-starch polysaccharides (Iji and Tivey, 1997).

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