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Effects of Dietary Supplementation of Canola Meal on Growth Performance, Nutrient Digestibility and its Economic Efficiency in Finishing Pigs

Kwangyeol Kim, Kwang Hyun Kim, Suhyup Lee, Santosh Ingale, Akshat Goel, Yohan Choi and Byung-Jo Chae*

Department of Animal Resources Science, College of Animal Life Sciences, Kangwon National University, Chuncheon-200 701, REPUBLIC OF KOREA.

**Corresponding author: BJ Chae; Email: bjchae@kangwon.ac.kr*

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ABSTRACT

Present study investigated the effects of dietary increasing levels of solvent-extracted canola meal (CM) as a substitute for soybean meal as an energy and amino acid source in finishing pigs. A total of 192 finishing pigs (Landrace × Yorkshire × Duroc; initial body weight of 48.62 ± 3 kg) were randomly allotted to 4 treatments on the basis of BW. There were 4 replicate pens in each treatment with 12 pigs per pen. Dietary treatments were basal diet supplemented with 0, 4, 8 and 12% canola meal. Experimental diets were fed in meal form for 35 days. Dietary inclusion of increasing levels of canola meals had no effects (P>0.05) on growth performance and ATTD of nutrients and energy. Total feed cost per pigs was linearly reduced (P<0.05) with increase in dietary canola meal level. However, dietary inclusion of canola meal has no effects (P>0.05) on total weight gain (TWG), total feed intake (TFI) and feed cost per kg weight gain (FCG). These results indicates that up to 12% canola meal can be included in finishing pig's diet without any adverse effect on growth performance and ATTD of nutrient. In addition, finisher pigs feed cost can be reduced with dietary inclusion of canola meal.

Keywords: canola meal, feed cost, finishing pigs, performance, soybean meal

Soybean meal is a major source of protein that determines the price of proteins for livestock feeding (Willis, 2003) but increase in speculative demand has resulted in increasing its price during last few years (Food price watch, 2014). Thus, pig farmers are subject to serious economic losses. In order to solve this problem, selection of reasonable alternatives for soybean meal can prove to be beneficial for reducing the cost of raw material.

Most commonly research substitute as replacement of soybean meal in pigs diets are DDGS, copra meal, palm kernel meal and rapeseed meal (Almeida *et al.*, 2013; Jaworski *et al.*, 2013). But, instability in the supply, nutritional imbalance, reduced productivity and palatability are some of the limitations with these raw materials. However, rapeseed meal has potential for being used as an alternative due to higher nutrients content in its bi-product produced during the oil extraction and about 35-40% crude protein, 2.3% lysine 10% crude fiber and relatively good amino acid composition (Thacker, 1990; Nasi and Siljander-Rasi, 1991). It is a residual product after extracting oil from seeds and the nutrients depend on the kind of seed, cultural environment and processing methods (Bell and Jeffer, 1976; Sauer *et al.*, 1982). Major limiting factor in use of rapeseed meal in animal diets is the higher content of erucic acid and glucosinolates which causes change in the thyroid tissue and acts as trophic factors to reduce the palatability and growth (Bell, 1993). Due to its rich content of crude protein (38-41%), it was recommended as a raw material as protein source with better amino acid composition to replace the soybean meal in growing-finishing pigs diet (Mullan *et al.*, 2000; Brand *et al.*, 2001; Roth Maier, 2004). Recently few studies have been conducted on the performance of laying hens supplemented with different concentration of canola (Gul *et al.*, 2012; Ahmad *et al.*, 2013) and reported the production of monounsaturated fatty acid (MUFA)-rich functional eggs without compromising there quality characteristics. Hickling (1994) reported that, dietary inclusion of 10 to 15% CM to fattening pigs, had no effect on the performance. However, studies on domestic canola meal are still incomplete and its usage is not investigated. Therefore, present study was conducted to investigate the effects of dietary increasing levels of solvent-extracted canola meal (CM) as a substitute for soybean meal as an energy and amino acid source on growth performance, apparent total tract digestibility (ATTD) of nutrients and its economic efficiency in finishing pigs

MATERIALS AND METHODS

The protocol for this experiment was approved and swine were cared according to the guidelines of the Institutional Animal Care and Use Committee of Kangwon National University, Chuncheon, Republic of Korea.

Animals and experimental design

A total of 192 finishing pigs (Landrace × Yorkshire × Duroc; initial body weight of 48.62 ± 3 kg) were randomly allotted to 4 treatments on the basis of BW. There were 4 replicate pens in each treatment with 12 pigs per pen. Dietary treatments were basal diet supplemented with 0, 4, 8 and 12% canola meal. Experimental diets were fed in meal form for 35 days. Experimental diets were formulated to contain 3,350 (kcal/kg) ME and 0.85% lysine. Vitamins and minerals were supplemented in all diets and all diets met or exceeded the National Research Council (NRC, 2012) nutrients requirements for finishing pigs.

Table 1. Proximate and amino acid composition of domestic canola meal sources

Item (%)	Domestic Canola meal
Dry Matter	88.63
Crude Protein	37.77
Ash	6.29
Crude Fiber	9.50
Calcium	0.66
Phosphorus	1.03
Neutral detergent fiber	25.06
Acid detergent fiber	16.18
Amino acid	
Essential	
Arginine	2.13
Histidine	0.97
Isoleucine	1.36
Leucine	2.51
Lysine	2.09
Methionine	0.74
Phenylalanine	1.44
Threonine	1.58
Tryptophan	0.37
Valine	1.72
Sub-mean	14.91
Non-essential	
Alanine	1.57
Aspartic acid	2.53
Cystine	0.91
Glutamic acid	6.34
Glycine	1.80
Proline	2.29
Serine	1.58
Tyrosine	0.95
Sub-mean	17.97
Total-mean	32.88

Table 2. Ingredient and chemical composition of experimental diets

Item	Domestic canola meal (%)			
	0	4	8	12
Cost ($, kg)	0.459	0.455	0.452	0.448
Ingredient (%)				
Corn	74.50	73.68	72.70	71.74
Soybean meal (44%)[1]	19.98	16.77	13.59	10.41
Domestic canola meal (37%)	0.00	4.00	8.00	12.00
Animal fat	2.00	2.11	2.29	2.46
Choline-chloride (50%)	0.06	0.06	0.06	0.06
$_L$-lysine HCl (78%)	0.34	0.35	0.36	0.37
$_{DL}$-methionine (99%)	0.06	0.05	0.03	0.01
$_L$-threonine (98.5%)	0.09	0.08	0.08	0.08
$_L$-tryptophan (10%)	0.32	0.35	0.37	0.39
TCP	0.80	0.84	0.88	0.91
Limestone	1.15	1.01	0.94	0.87
Salt	0.25	0.25	0.25	0.25
Mineral premix[2]	0.20	0.20	0.20	0.20
Vitamin premix[3]	0.20	0.20	0.20	0.20
Phytase	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00
Calculated chemical composition (%)				
ME (kcal/kg)	3,350	3,350	3,350	3,350
Crude Protein	15.50	15.50	15.50	15.50
Calcium	0.75	0.75	0.75	0.75
Available phosphorus	0.23	0.23	0.23	0.23
SID lysine	0.85	0.85	0.85	0.85
SID met+cys	0.48	0.48	0.48	0.48
SID threonine	0.52	0.52	0.52	0.52
SID tryptophan	0.15	0.15	0.15	0.15

[1] Soybean meal was replaced by domestic canola meal (SBM: 0.662 $/kg; CM: 0.462 $/kg).
[2] Supplied per kg diet: 150 mg Fe, 96 mg Cu, 72 mg Zn, 46.49 mg Mn, 0.9 mg I, 0.9 mg Co, 0.336 mg Se.
[3] Supplied per kg diet: 10,000 IU Vit A, 2,500 IU Vit D3, 50 IU Vit E, 1.5 mg Vit K3, 1.5 mg Vit B1, 5 mg Vit B2, 3 mg Vit B6, 0.025 mg Vit B12, 15 mg pantothenic acid, 35 mg niacin, 0.15 mg biotin, 1 mg folic acid.

Table 3. Effects of dietary inclusion of domestic canola meal on growth performance of finishing pigs

Item	Domestic canola meal (%)				SEM[1]	P-value	
	0	4	8	12		Linear	Quadratic
Initial BW (kg)	49.20	49.01	49.01	49.08	0.20	0.719	0.550
Final BW (kg)	82.80	82.31	82.14	81.97	0.33	0.085	0.621
ADG (g)	960	951	947	940	10.54	0.205	0.942
ADFI (g)	2,673	2,658	2,651	2,678	15.08	0.908	0.212
FCR	2.78	2.79	2.80	2.85	0.03	0.212	0.586

1 Standard error of means.

Experimental procedure and chemical analyses

The pigs were individually weighed and consumption of feed in each pen was measured at the end of the experiments. Growth performance in terms of average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) was calculated during the feeding trial. Feed samples from each dietary treatment were collected and analyzed for proximate chemical compositions. To evaluate the effects of dietary treatments on the ATTD of energy and nutrients, 0.25% chromic oxide (an inert indigestible indicator) were included in each diet from d 28 to 35 of each experiment. Fecal grab samples were collected from the floor of each pen during last 4 days of each experiment to determine the ATTD of DM, GE and CP. The fecal samples were pooled within pen and dried in a forced air drying oven at 60°C for 72 h, and ground in a Wiley mill (Thomas Model 4 Wiley Mill, Thomas Scientific, Swedesboro, NJ) using a 1-mm screen and used for chemical analysis.

Experimental diets and excreta samples were analyzed in triplicate for DM (Method 930.15), CP (Method 990.03), ash (Method 942.05), Ca and P (Method 985.01) according to the AOAC (2007) methods. Gross energy of diets and excreta were measured using a bomb calorimeter (Model 1261, Parr Instrument Co., Molin, IL), while chromium concentrations were determined with an automated spectrophotometer (Jasco V-650, Jasco Corp., Tokyo, Japan) according to the procedure described by Fenton and Fenton (1979).

Economic analyses

The feed cost (FC) was calculated based on the price of ingredients used and then employed to calculate the feed cost per kg body weight gain (FCG) and total feed cost (TFC) as follows:

FCG = TFI×FC/TWG

TFC = FC×TFI

where, TFI=total feed intake and FC=feed cost

TWG=total weight gain per pig (kg).

Statistical analyses

Data generated in the present experiment were analyzed as a randomized complete block design using the GLM procedure of SAS (SAS Institute Inc., Cary, NC). Orthogonal polynomials were used to evaluate linear and quadratic effects of dietary increasing levels (0, 4, 8 and 12%) domestic CM. The pen was used as the experimental unit for the analysis of growth performance and nutrient digestibility. Probability values of ≤ 0.05 were considered significant.

RESULTS

Chemical composition

Chemical composition of domestic canola meal is presented in Table 1. It contains 88.63% DM, 37.77% CP, 9.5% crude fiber, 0.66% calcium, 1.03% P and 2.09% lysine. Canola meal was included in diets with equal replacement of soybean meal. All experimental diets were formulated to contain 3,350 Kcal ME, 15.50% CP and 0.85% lysine (Table 2).

Growth performance

Effect of dietary inclusion of canola meal on growth performance is presented in Table 3. Dietary increasing levels of canola meal had no effects (P>0.05) on final body weight and overall (d 0-35) ADG, ADFI and F:G of finishing pigs. All pigs remained in good health during experimental period and there was no mortality in any group.

Nutrient digestibility

Effects of dietary inclusion of canola meal on ATTD of nutrients and energy are presented in Table 4. Dietary inclusion of increasing levels of domestic canola meal had no effects (linear or quadratic; P>0.05) on ATTD of DM, CP, GE and ash. Also digestibility of all nutrients remained within normal range.

Economic analysis

Dietary inclusion of increasing levels of CM has resulted in reducing (linear; P<0.05) the total feed cost TFC of finishing pigs (Table 5). Dietary inclusion of

8% or 12% of CM reduced TFC to almost 1$ per pig. However, no difference (P<0.05) was observed in the FC ($/kg), TWG (kg/pis), TFI (kg/pig) and FCG ($/kg wt. gain) of the finishing pigs.

Table 4. The effect of dietary increasing levels of domestic canola meal on apparent total tract digestibility of nutrients (ATTD) in finishing pigs

Item	Domestic canola meal (%)				SEM[1]	P-value	
	0	4	8	12		Linear	Quadratic
DM	77.96	77.22	77.07	76.61	0.72	0.238	0.854
GE	79.29	78.82	78.79	78.25	0.73	0.389	0.958
CP	72.16	71.84	72.17	70.88	0.66	0.271	0.492
Ash	40.06	39.59	40.21	38.77	0.68	0.327	0.504

1 Standard error of means.

DISCUSSION

Soybean is considered as the most favorable protein source in pig's diets. However, in last few years, canola meal being cheaply available as byproduct is catching an eye of the nutritionist to replace the soybean meal in pigs diet to reduce feed cost. The major difference between rapeseed meal and canola meal are the presence of high glucosinolate and erucic acid content in former with valid toxicity and palatability concerns (Khajali and Slominski, 2012). The breeding of canola from rapeseed has made canola meal a conventional feedstuff for swine, especially for grower-finishing pigs (Canola Council of Canada, 2009).

Table 5. Effects of dietary increasing levels of domestic canola meal on the production cost in finishing pigs

Item	Domestic canola meal (%)				SEM[1]	P-value	
	0	4	8	12		Linear	Quadratic
FC ($/kg)	0.459	0.455	0.452	0.448			
TWG (kg/pis)	33.60	33.30	33.13	32.89	0.38	0.204	0.942
TFI (kg/pig)	93.54	93.04	92.78	93.73	0.53	0.908	0.212
TFC ($/pig)	42.968	42.379	41.915	41.995	0.12	0.011	0.206
FCG ($/kg wt. gain)	1.279	1.273	1.265	1.277	0.01	0.858	0.584

[1]Standard error of means.

The breeding efforts in canola to reduce the concentrations of the main anti-nutritional factors glucosinolates and erucic acid were groundbreaking. These efforts produced canola meal with an enhanced nutritional value in comparison to rapeseed meal. Further, dietary inclusion of canola meal has been reported to reduce the reliance on soybean meal (Robertson *et al.*, 2000). Although canola, i.e., low erucic acid, low glucosinolate rapeseed, is a major oilseed crop, and CM has been a feedstuff for more than 30 years, knowledge about the feed value of recently produced CM for weaned pigs is limited. Nutrient availability is an abstract concept, which cannot be measured but it can be estimated (Sibbald, 1987). However, Studies have suggested that amino acids in swine diets should be formulated on the basis of true or standardized amino acid digestibility (Nyachoti *et al.*, 1997). Thus, mixing ratio for the present experiment was created by applying the standard ileal digestibility (SID) that has shown good efficiency on swine.

It is known that the efficiency of nutrient and energy digestibility of feed ingredients in pig diets is usually affected by dietary supplements, there processing methods (De Vries *et al.*, 2012) and feeding levels (Noblet and Shi, 1994). It has been reported that inclusion of 15% CM in the diet has decreased the feed intake by 41 g, feed conversion efficiency by 10% and increased the carcass fat, while inclusion of 13.2% CM, has decreased the daily gain by 8% and feed conversion efficiency by 6% with no impact on carcass, meat, or fat quality (Wetscherek *et al.*, 1990; 1992). In contrast, the present study reported that dietary inclusion of upto 12% CM had no effect on final BW, ADG, ADFI and FCR of the finishing pigs. Present findings are consistent with results of Roth-Maier *et al.* (2004) who reported no impact of dietary inclusion of canola meal on growth performance and slaughter data during earlier period (period I+II), however, improved growth in the later stages of grower period when supplemented with different concentration of canola meal. This might be due to the use of lower concentration of canola meal and selective breeding program used for improving the canola variety for reducing the contents of erucic acid and glucosinolates. Further, some authors indicated that young pigs are more affected by glucosinolates (Corino *et al.*, 1991) while other suggested finishing pigs are more sensitive (Roth-Maier *et al.*, 2004) but maximum tolerable level of dietary glucosinolates for weaned pigs is still to be established.

Among vegetable protein sources, soybean meal is well known due to its best profile of certain essential amino acids (Cromwell, 1999), whereas, canola meal is rich in fiber content and contains about three times higher fiber than soybean meal. It has been reported that feed stuff containing higher fibers reduce the digestibility, increase endogenous secretions and decrease hydrolysis and absorption of nutrients (Bell, 1993; Wilfart *et al.*, 2007) in pigs. Lysine is often the first limiting amino acid in farm animal feeds (Bell, 1993) but its additional supplementation in the diet increases its uptake (Schneider *et al.*, 2010). Ileal lysine digestibility of rapeseed meal is about 10% lower than that of soybean meal (Sauer and Ozimek, 1986; CVB, 1991). However, in the present study inclusion of different concentration of CM has been accompanied with supplementation of crystalline amino acids to maintain the similar ilium digestibility (SID) of amino acid including lysine that has resulted in no variation in digestibility of DM, GE, and CP of finishing pigs. In the present study, lack of detrimental effects of CM on growth performance and ATTD of nutrients might be due to the fact that diet was formulated on the bases of SID amino acid systems that reduce the risks associated with increasing inclusions of high fiber, high protein co-products in swine diets (Zijlstra and Payne, 2007).

The use of soybean is limited due to its high cost (Swick, 1999). Among vegetable protein meals, canola meal stands second (Nowlin, 1991) but contains less gross energy and protein (Bell, 1993). However, reduced total feed cost for animal production without negatively effecting growth could be beneficial for the farmers. In the present study replacement of the soybean meal with upto 12% CM has reduced the TFC ($/pig) without effecting the performance and digestibility of finishing pigs. This is in line with the earlier reports where low price of canola meal and its better feed efficiency, with increasing levels in diets resulted in decrease in the cost of production (Nascimento *et al.*, 1998; Naseem et al 2006) in chicken. But as per our knowledge, economic aspect of using canola meal in pigs has not been explored much. The present study shows the potential way to reduce the production cost by substituting protein source in pig's diet. Canola meal, being easily available and cheap constituent for feed additive in comparison to soybean meal, is a high energy protein feedstuff that provides additional flexibility (Beltranena and Zijlstra, 2011) and can prove to be an effective replacement for the feed industry in the near future.

CONCLUSION

In view of the SID and energy from finishing pigs, supplementation of canola meal up to 12% does not affect the digestibility and growth performance and can be included in finishing pig's diet. Further, dietary inclusion of up to 12% canola meal resulted into reduced feed cost.

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