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Technical Note

Effects of Diets with Graded Levels of Canola Meal on the Growth Performance, Meat Qualities, Relative Organ Weights, and Blood Characteristics of Broiler Chickens

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ABSTRACT

This experiment was conducted to evaluate the dietary supplementation of canola meal (CM) on the growth performance, carcass characteristics, antibody titers against Newcastle disease virus and Infectious bronchitis virus, and blood profiles of broiler chickens. In total 600 day-old feather-sexed Ross male broiler chicks were randomly assigned into five treatments with six replicates of 20 birds each for 35 days. Treatments consisted of five experimental diets containing 0 (control), 3, 5, 10, or 15% canola meal (CM). Final body weight (BW) was not affected by the dietary treatments. Daily BW gain (DWG) and feed intake linearly decreased as dietary CM inclusion increased during the starter phase ($p<0.0001$), but not during the grower and total rearing periods. Chicks fed the diet with 15% CM presented the lowest DWG during the starter phase. Breast meat yield of CM-fed chicks linearly decreased as CM inclusion level increased ($p=0.0014$). Dietary CM supplementation did not influence organ relative weights, except for the spleen, meat quality, or blood profile. The results suggest that the CM may replace soybean meal (SBM) with no detrimental effects on overall growth performance or physiological responses of broiler chickens. However, it is recommended that supplementing excess amount of CM into broilers' diet should be taken into account in practical diet formulation as it could impair growth performance at early age and lower breast meat yields.

INTRODUCTION

The increase in soybean meal (SBM) prices in recent years had a strong impact in poultry feed costs. In order to reduce the burden of increased feed cost, several studies have focused on the exploration and efficient use of alternative feedstuffs. Rapeseed or canola meal is commonly used in animal feeds around the world and it ranks as the most widely traded plant protein sources after SBM (USDA, 2011). The term canola was coined to differentiate it from rapeseed; it is also called the 'double-zero rapeseed' (i.e., with low erucic acid and glucosinolate levels). Canola meal (CM), which is a by-product of canola oil extraction, has high protein levels with high methionine and cystine contents; however, it is poor in lysine like many plant-derived protein feedstuffs (Khajali & Slominski, 2012). CM is available at relatively low price and thus, its inclusion level may be increased to reduce the poultry feed costs (Klein *et al*., 1981).

Although CM is an economically viable alternative to SBM, there are several reports of reduced performance of broiler chickens when CM is replaced for a significant amount of SBM. Mushtaq *et al*. (2007) reported that the BW gain was significantly reduced when 30% CM was supplemented in the diets of 1- to 21-d-old broilers. The BW of broilers fed a diet supplemented with 7 and 10% CM decreased by 8.9 and 13.2%, respectively (Borcea *et al*., 1996). In contrast, it has been reported that the replacement of 100% SBM by CM maintained broiler performance, provided diets are supplemented with lysine (Leeson *et al*., 1987; Kocher *et al*., 2000). The observed discrepancy in CM feeding values prompted us to study the effects of the dietary inclusion of graded levels of CM on the growth performance of broilers. In addition, meat quality and various physiological responses to CM feeding were monitored.

MATERIALS AND METHODS

Diets, animals and management

The CM used in this study was produced and provided by CJ Cheil Jedang Corp., Korea. The CM samples were first analyzed for their chemical composition using the methods of AOAC (2000) in the officially accredited feed analysis laboratory (Korea Feed Ingredients Association, Seoul, South Korea) and are presented in Table 1. The experimental diets containing 0, 3, 5, 10, or 15% CM at the expense of SBM were formulated to meet the nutritional requirements of broilers according to the NRC (1994), as shown in Tables 2 and 3. All diets were formulated to contain identical levels of true metabolizable energy corrected for nitrogen (TMEn), crude protein (CP), available lysine and total sulfur amino acids.

Six hundred one-day-old feather-sexed Ross male broiler chicks were received from a local hatchery, individually weighed, and randomly divided into 30 pens (20 chicks per pen, six pens per treatment) on rice straw litter. A 23/1 light/dark cycle was used throughout the experimental period. At 21 days of age, all chicks were given an attenuated live mixed vaccine (Nobilis Ma5+Clone 30, MSD AH Korea Ltd., Korea) by eye drop.

The diets and water were provided for *ad libitum* for 35 days. The chicks were initially reared at 33ºC and the room temperature was gradually decreased to reach 23ºC and kept thereafter. Body weight (BW) and feed intake on a pen basis were recorded weekly and used to calculate feed conversion rate (FCR).

Sampling

At the end of the experimental period (14 days after vaccination), 12 birds per treatment (two birds per replicate) were randomly selected, individually weighed, and sacrificed, when blood samples were collected. Sera were obtained by gentle centrifugation and stored at 20ºC until use. Immediately after blood sampling, the liver, spleen, abdominal fat, breast and leg were removed and weighed, and their weight expressed as grams of organ per 100 g BW. All animal care procedures were approved by Institutional Animal Care and Use Committee in Konkuk University.

Measurement of humoral antibodies

In order to evaluate broilers' humoral immune response to vaccination, serum samples were analyzed

Table 1 – Analyzed chemical composition of canola meal (as-is basis)

Item	Value
Moisture, %	6.80
CP, %	39.9
Ether extract, %	2.16
Crude fiber, %	10.8
Crude ash, %	6.80
Amino acids	
Tryptophan, %	0.29
Threonine, %	1.83
Serine, %	1.90
Proline, %	2.61
Valine, %	1.39
Isoleucine, %	1.53
Leucine, %	2.70
Tyrosine, %	1.13
Methionine + Cyst(e)ine, %	1.28
Lysine, %	1.98
Glycine, %	1.83
Alanine, %	1.48
Arginine, %	1.83
Glutamate + Glutamine, %	6.23
Aspartate + Asparagine, %	2.53
Histidine, %	1.04
Phenylalanine, %	1.45
Minerals	
Calcium, %	0.62
Phosphorus, %	1.24
Sodium, %	0.01
Chloride, %	0.47
Potassium, %	0.98
Magnesium, %	0.62
Zinc, mg/kg	55
Sodium, mg/kg	101
Manganese, mg/kg	55
Copper, mg/kg	0.81
Iron, mg/kg	181
Nickel, mg/kg	2.56
Selenium, mg/kg	0.35
Vitamins	
Vitamin E, mg/kg	12.9
Vitamin D_3, IU/kg	3,960
Glucosinolates, µmol/g	2.55
Gross energy, kcal/kg	4,471

Table 2 – Ingredients and compositions of experimental diets (starter)1,2

Ingredients (%)	Control	CM 3	CM 5	CM 10	CM 15
Corn	42.05	42.59	42.96	43.87	44.07
Wheat	10.00	10.00	10.00	10.00	10.00
Soybean meal	31.61	29.90	28.74	25.84	21.60
Canola meal	0.00	3.00	5.00	10.00	15.00
Corn gluten meal	3.12	2.77	2.53	1.94	2.16
Wheat bran	5.80	4.39	3.46	1.14	-
Tallow	3.50	3.50	3.50	3.50	3.50
Vitamin premix[3]	0.15	0.15	0.15	0.15	0.15
L-Lys-HCl, 78%	0.01	0.01	-	-	0.02
Di-calcium phosphate	1.88	1.87	1.87	1.86	1.84
DL-Met, 98%	0.15	0.14	0.14	0.13	0.12
Limestone	1.22	1.19	1.17	1.13	1.10
Choline-Cl, 50%	0.06	0.04	0.03	-	-
Salt	0.30	0.30	0.30	0.30	0.30
Trace mineral premix[3]	0.15	0.15	0.15	0.15	0.15
L-Thr, 98%	0.01	-	-	-	-
Chemical composition (calculated values)					
CP, %	21.50	21.50	21.50	21.50	21.50
CF, %	3.14	3.24	3.31	3.47	3.68
Ca, %	1.00	1.00	1.00	1.00	1.00
Avail. P, %	0.45	0.45	0.45	0.45	0.45
Avail Lys, %	0.96	0.96	0.96	0.96	0.96
Avail Cys+Met, %	0.79	0.80	0.81	0.82	0.83
Avail Thr, %	0.71	0.70	0.71	0.71	0.72
TMEn, kcal/kg	3,000	3,000	3,000	3,000	3,000

[1] CM, canola meal; TMEn, nitrogen corrected true metabolizable energy.

[2] Control, basal diet; CM 3, applied with 3% canola meal; CM 5, applied with 5% canola meal; CM 10, applied with 10% canola meal; CM 15, applied with 15% canola meal.

[3] Vitamin and mineral premix provided following nutrients per kg of diet: vit A, 15,000 IU; vit D_3, 7,500 IU; vit E, 30 IU; vit K_3, 4.5 mg; vit B_2, 9mg; vit B_6, 4.5 mg; vit B_{12}, 0.02 mg; niacin, 75 mg; Ca-pantothenate, 19.5 mg; Folic acid, 19.5 mg; Cu, 7.5 mg; I, 0.38 mg; Mn, 165 mg; Zn, 150 mg; Se, 0.45 mg; Fe, 60 mg; Co, 7.5 mg.

for anti-NDV and anti-IBV antibody titers using an ELISA using commercial kits, following manufacturer's direction (IDDEX Laboratory, Inc., Korea).

Measurements of blood parameters

The activities of the enzymes glutamic-oxaloacetic transaminase (GOT) and glutamic-pyruvic transaminase (GPT) in the serum samples were measured according to the colorimetric method, as previous described (An *et al*., 2007).

Determination of meat quality

The breast muscles were evaluated for cooking loss, pH, and color 24 h *postmortem*. To determine the cooking loss, 60 g of breast meat was boiled individually in polyethylene bags immersed in 80°C water bath for 30 min and cooled at room temperature for 30 min. Cooking loss was calculated as the difference between uncooked and cooked weights. Breast meat pH values were estimated in triplicate with a pH meter (Model 340, Mettler-Toledo, Switzerland). Briefly, 1 g of breast meat was cut into small pieces and homogenized with 9 mL of distilled water for 1 min in an Ultra-Turrax (Model No. T25, Janken and Kunkel, Germany). The instrumental color of fresh meat, including lightness (L*), redness (a*) and yellowness (b*), was measured by a reflectance colorimeter (CR 210, Minolta, Japan) using illuminant source C. Color was measured in triplicate on the bone-side surface of each sample. The colorimeter was calibrated throughout the study using a standard white ceramic tile.

Statistical analysis

All the data obtained in this study were analyzed using the GLM procedure of SAS software (SAS Institute, 2002). Pen was considered an experimental unit. Orthogonal polynomial contrasts were used to determine the linear and quadratic effects of dietary canola meal according to the following model: $Y=\mu+\alpha+\varepsilon$, where Y was the observed response variables; μ was the overall mean; α was the effect of diet and ε was the random error. Statistical significance was accepted at $p<0.05$.

Table 3 – Ingredients and compositions of experimental diets (finisher)1,2

Ingredients (%)	Control	CM 3	CM 5	CM 10	CM 15
Corn	47.15	47.52	47.64	47.95	48.25
Wheat	10.00	10.00	10.00	10.00	10.00
Soybean meal	26.35	24.50	22.98	19.18	15.40
Canola meal	-	3.00	5.00	10.00	15.00
Corn gluten meal	1.91	1.65	1.65	1.63	1.62
Wheat bran	7.30	6.11	5.56	4.17	2.76
Tallow	3.50	3.50	3.50	3.50	3.50
Vitamin premix[3]	0.12	0.12	0.12	0.12	0.12
L-Lys-HCl, 78%	0.07	0.06	0.07	0.08	0.09
Di-calcium phosphate	1.34	1.33	1.32	1.30	1.28
DL-Met, 98%	0.08	0.07	0.06	0.03	0.01
Limestone	1.59	1.57	1.55	1.52	1.48
Choline-Cl, 50%	0.08	0.06	0.05	0.02	-
Salt	0.30	0.30	0.30	0.30	0.30
Trace mineral premix[3]	0.15	0.15	0.15	0.15	0.15
L-Thr, 98%	0.06	0.06	0.05	0.05	0.04
Chemical composition (calculated values)					
CP, %	19.00	19.00	19.00	19.00	19.00
CF, %	3.55	3.66	3.74	3.95	4.15
Ca, %	1.00	1.00	1.00	1.00	1.00
Avail. P, %	0.35	0.35	0.35	0.35	0.35
Avail Lys, %	0.88	0.88	0.88	0.88	0.88
Avail Cys+Met, %	0.66	0.66	0.66	0.66	0.66
Avail Thr, %	0.67	0.67	0.67	0.67	0.67
TMEn, kcal/kg	3,000	3,000	3,000	3,000	3,000

[1] CM, canola meal; TMEn, nitrogen corrected true metabolizable energy.

[2] Control, basal diet; CM 3, applied with 3% canola meal; CM 5, applied with 5% canola meal; CM 10, applied with 10% canola meal; CM 15, applied with 15% canola meal.

[3] Vitamin and mineral premix provided following nutrients per kg of diet: vit A, 15,000 IU; vit D_3, 7,500 IU; vit E, 30 IU; vit K_3, 4.5 mg; vit B_2, 9mg; vit B_6, 4.5 mg; vit B_{12}, 0.02 mg; niacin, 75 mg; Ca-pantothenate, 19.5 mg; Folic acid, 19.5 mg; Cu, 7.5 mg; I, 0.38 mg; Mn, 165 mg; Zn, 150 mg; Se, 0.45 mg; Fe, 60 mg; Co, 7.5 mg.

RESULTS AND DISCUSSION

According to the chemical analysis, CM, on an as-is basis, contained 6.80% of moisture, 39.9% of CP, 2.16% of ether extract, 10.8% of crude fiber, and 6.80% of crude ash, respectively, and these were comparable with NRC values (1994). In addition, CM amino acid profiles (Table 1) are considered favorable compared with those of SBM, although CP and lysine levels in CM vs. SBM are relatively low (Khajali and Slominski, 2012). A value of 1,770 kcal of TMEn/kg was assigned to the CM for the formulation of the experimental diets in this study.

Growth performance of broiler chicks fed diets with varying CM levels is presented in Table 4. Final BW at 35 days of age was not affected by dietary treatments. However, DWG linearly ($p<0.001$) decreased as CM inclusion levels increased between 1-21 d of age. The chicks fed the diet with 15% CM showed the lowest daily weight gain. A linear trend for feed intake was determined with increasing dietary CM levels during 1-21 d of age ($p=0.0204$). However, DWG, feed intake, and FCR were not affected by CM dietary levels during the grower phase. When data were pooled for total rearing period (1-35 d), no significant effects of dietary CM levels on DWG, feed intake or FCR were observed.

In most studies on the supplementation of broiler diets with CM, the growth performance of broiler chickens was not affected when nutrient density, especially of lysine, was maintained in the experimental diets. For example, Leeson *et al*. (1987) did not find any significant effects of replacing SBM with CM on feed intake, BWG and feed efficiency. In addition, it was shown that dehulled CM added in broiler diets at the level of 20% had no adverse effect on overall growth performance (Baloch *et al*., 2003). In the present study, the overall growth performance was not affected by CM dietary levels during grower phase and total rearing period, in agreement with those results.

However, in this study, with increasing levels of CM, DWG linearly decreased compared with the control during the starter phase ($p<0.0001$). In several studies, a reduction in growth performance of young chicks was reported when high CM levels were added

Table 4 – The dietary effect of canola meal on growth performance in broiler chickens1,2,3

Items	Control	CM 3	CM 5	CM 10	CM 15	SEM	p-value	
							Linear	Quadratic
Initial body weight, g/bird	44.50	44.46	44.43	44.39	44.46	0.10	0.7216	0.4849
Final body weight, g/bird	1700.82	1651.20	1692.45	1688.69	1587.25	41.05	0.1326	0.3688
Body weight gain, g/bird/d								
1-21 d	34.41	31.32	32.05	32.53	29.51	0.46	<0.0001	0.9866
22-35 d	66.70	67.78	69.64	68.65	65.94	2.50	0.7908	0.2952
1-35 d	47.32	45.91	47.09	46.98	44.08	1.17	0.1328	0.3680
Feed intake, g/bird/d								
1-21 d	56.63	51.71	52.46	52.42	51.27	1.11	0.0204	0.1034
22-35 d	134.50	132.14	132.37	134.61	134.59	1.76	0.5591	0.4819
1-35 d	85.66	84.71	85.07	85.94	85.57	0.73	0.6239	0.7608
Feed conversion ratio, feed/gain								
1-21 d	1.65	1.65	1.64	1.61	1.74	0.04	0.1634	0.1006
22-35 d	2.03	1.96	1.90	1.97	2.05	0.08	0.7155	0.2258
1-35 d	1.81	1.85	1.81	1.83	1.94	0.05	0.0878	0.2995

[1] CM, canola meal; SEM, pooled standard error of the means.

[2] Control, basal diet; CM 3, applied with 3% canola meal; CM 5, applied with 5% canola meal; CM 10, applied with 10% canola meal; CM 15, applied with 15% canola meal.

[3] Values are presented as the mean (n=6, each group).

to the diet. Mushtaq *et al*. (2007) reported that the supplementation of 30% CM into broiler diets reduced BWG from 1 to 21 d of age. The addition of 7 and 10% CM negatively affected broiler DWG and FCR, resulting in a significant BW depression (Borcea *et al*., 1996). On the other hand, no clear negative effect of dietary CM addition on the growth of broiler chickens was reported. For example, Nassar & Arscott (1986) reported that a diet with 50% replacement of SBM with CM did not negatively affect the early growth of broiler chickens. A similar result was reported by Min *et al*. (2009), who did not find any differences in the early growth of broilers fed a diet containing up to 10% CM.

The impaired growth performance caused by increasing CM levels at early ages of broiler chicks as shown in this study should not be attributed to the composition of the CM-added diets as all experimental diets were equally formulated on the basis of TMEn and available limiting AA. The plausible reason(s) would be that CM contains high fiber and some anti-nutritional factors, such as NSP, phytic acid, glucosinolates and sinapine (Clandinin, 1961; Khajali & Slominski, 2012), thus reducing feed intake which consequently led to early growth depression. Indeed, in the present study, there was a significant linear trend of dietary CM levels affecting feed intake during the starter phase (p=0.0204). However, observation that there was no significant effect on feed intake during the grower phase suggests that CM is palatable to old broilers.

Carcass characteristics and meat qualities of broiler chicks fed diets with varying levels of CM are presented in Table 5. There were no significant differences in relative weights of liver, abdominal fat and legs, except for spleen. The relative weight of breast meat in chicks fed diets with 10 and 15% CM was linearly decreased (p=0.0014). There were no significant linear and quadratic trends of dietary levels of CM affecting cooking loss, color and pH of breast meats (Table 5). The CM, as it contains low levels of lysine and arginine, may affect the carcass characteristics and breast yield. Jung *et al*. (2012) found that addition of CM at the level of 7.5% in diet significantly (p<0.05) decreased the carcass yield and marginally (p>005) breast meat yield in broiler chickens. Mushtaq *et al*. (2007) also reported that the breast meat was reduced in broiler chickens fed a diet containing 30% CM diet with only 0.8% available lysine. The yield of breast meat is considered sensitive to the quantity and composition of dietary amino acids, and thus careful consideration should be taken when diet with high levels of CM are fed.

The activities of GOT and GPT in serum and the antibody titers of against NDV and IBV were not affected by CM feeding (data not shown). The latter results agreed with those from Mushtaq *et al*. (2007) who found no significant difference in antibody titer against NDV of broilers fed diets containing 20 or 30% CM. The measurement of serum GOT and GPT activities, indicative of tissue damage in bird, is a valuable tool to determine a safe inclusion level for non-conventional feedstuff (Diaz *et al*., 2003). Earlier study revealed that a significant amount of crambe meal inclusion, a locally produced non-conventional source, resulted in elevation of serum GOT level (Kloss

Table 5 – The dietary effect of canola meal on carcass characteristics and meat qualities in broiler chickens1,2,3

Items	Control	CM 3	CM 5	CM 10	CM 15	SEM	p-value	
							Linear	Quadratic
Liver, g/100g BW	1.91	2.10	1.97	2.24	2.16	0.11	0.0642	0.4111
Spleen, g/100g BW	0.11	0.11	0.12	0.11	0.09	0.01	0.0181	0.0768
Abdominal fat, g/100g BW	1.07	1.22	1.11	1.05	1.01	0.06	0.0794	0.2658
Breast muscle, right, g/100g BW	8.45	8.80	8.34	8.06	7.46	0.26	0.0014	0.2450
Leg muscle, right, g/100g BW	9.37	9.32	9.28	9.27	9.50	0.16	0.5720	0.3458
Cooking loss, %	36.95	35.95	36.14	34.43	36.31	0.77	0.3321	0.0841
CIE[4]								
L*	60.84	59.43	61.55	59.32	61.79	0.90	0.5381	0.2512
a*	0.69	0.92	0.47	0.81	1.04	0.17	0.1616	0.3041
b*	8.23	8.29	8.85	7.97	9.51	0.51	0.1545	0.3517
pH	5.83	5.89	5.77	5.95	5.86	0.04	0.1991	0.5710

[1] CM, canola meal; SEM, pooled standard error of the means.

[2] Control, basal diet; CM 3, applied with 3% canola meal; CM 5, applied with 5% canola meal; CM 10, applied with 10% canola meal; CM 15, applied with 15% canola meal.

[3] Values are presented as the mean (n=6, each group).

[4] CIE; commission international de I'Eclairage, L*; lightness, a*; redness, b*; yellowness.

et al., 1996). However, the CM used in this study did not adversely affect blood profiles and response of antibody production.

In conclusion, the canola meal can replace SBM without any detrimental effects on overall growth performance and physiological responses of broiler chickens. However, the using excessive amount of CM lowered growth performance, especially at early ages, and breast meat yield of broiler chickens, of which results needs to be considered in practical feed formulation.

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