Performance, and thyroid gland, liver and kidney functions in broilers fed diets containing expeller-extracted canola meal

T. A. Woyengo, E. Kiarie, and C. M. Nyachoti
Department of Animal Science, University of Manitoba, Winnipeg, Manitoba, Canada. R3T 2N2

ABSTRACT Information on the effect of including expeller-extracted canola meal (EECM) in broiler diets on performance, and thyroid gland, liver and kidney functions and anaemia is limited. Thus, a study was conducted to determine the effect of including EECM in diets for broilers on performance; thyroid gland, liver and kidney sizes; and haemoglobin content in blood and haematocrit. Two hundred one-day-old male broiler chicks were divided into 40 groups of 5 birds balanced for body weight and fed 5 diets in a completely randomised design (8 groups per diet) from day 1 to day 21 of age. The diets were a complete corn-soybean meal-based basal diet with 0, 10, 20, 30 or 40% of EECM. The diets were formulated to be the same in metabolizable energy, crude protein, calcium, non-phytate phosphorus, and standardized ileal digestible methionine, lysine and threonine contents. The EECM contained (% of dry matter) 37.8% crude protein, 0.74% methionine, 2.14% lysine, 1.62% threonine, 1.61% valine, 1.23% isoleucine, 2.57% leucine, 1.41% phenylalanine, 2.12% arginine, 0.97% histidine and 8.03 μmol/g of glucosinolates. An increase in dietary level of EECM from 0 to 40% resulted in a linear decrease in feed intake (P < 0.001) by 4.8 g per 21-day period for each 1% increase in EECM and body weight gain (P < 0.001) by 6.0 g per 21-day period for each 1% increase in EECM. An increase in dietary level of EECM also resulted in a linear depression in feed conversion ratio (P < 0.001) by 0.004 g/g per 1% of EECM inclusion. However, an increase in dietary level of EECM from 0 to 40% resulted in a linear increase (P < 0.001) in the liver weight and a quadratic increase in kidney weight relative to live body weight. An increase in dietary level of EECM also tended to linearly increase the heart (P = 0.069). There was no effect of dietary treatment on thyroid gland size relative to live body weight, and on the blood haemoglobin content, and haematocrit. In conclusion, an increase in dietary level of EECM resulted in reduced growth performance and may interfere with liver and kidney functions likely due to increased dietary concentration of glucosinolates. Thus, the amount of EECM included in broiler diets should be based on the desired growth performance and the cost of the EECM.

Key words: broiler, performance, liver and kidney functions, anemia, expeller-extracted canola meal

INTRODUCTION

Canola meal is widely used as a protein source in poultry diets. Solvent and expeller extraction methods are used to obtain canola oil (Spragg and Mailer, 2007). However, the temperature and moisture conditions that canola meal is subjected to during oil extraction vary depending on the oil extraction method (Spragg and Mailer, 2007). Processing temperature and moisture are known to affect availability of nutrients in a feedstuff. Also, processing temperature is known to affect the content and composition of glucosinolates in canola meal (Jensen et al., 1995), which reduces growth performance of animals by reducing feed intake, interfering with thyroid, liver and kidney functions, and by causing anemia (Tripathi and Mishra, 2007). Thus, it is critical to determine the nutritive value of canola meals produced by different methods and the safety of their inclusion in diets to optimize their utilization in formulating poultry diets.

The nutritive value of SECM has been evaluated in several poultry studies and has been reviewed (Bell, 1993). We recently observed higher digestible amino acid and metabolizable energy contents for of EECM than for SECM fed to broilers (Woyengo et al., 2010), implying that the EECM can result in better poultry performance than SECM. However, there is lack of information on the effect of including EECM in diets for poultry on performance, and thyroid gland, liver and kidney functions, and anemia. Therefore, the objective of this study was to determine the effect of including EECM in diets for broilers on performance; thyroid gland, liver and kidney sizes; hematocrit; and blood hemoglobin content.

MATERIALS AND METHODS

Two hundred one-day-old male broiler chicks of the Ross 308 strain were obtained from a commercial hatchery. The chicks were divided into 40 groups of 5 birds balanced for body weight, and each group was housed in a cage in electrically heated Petersime battery brooders (Incubator Company, Gettysburg, OH). The brooder and room temperatures were set at 32 and 29°C, respectively, during the first week. Thereafter, heat supply in the brooder was switched off and room temperature was maintained at 29°C throughout the experiment. All experimental procedures were reviewed and approved by the University of Manitoba Animal Care Protocol Management and Review Committee and birds were handled in accordance with the guidelines described by the Canadian Council on Animal Care (CCAC, 1993).

The experimental diets included a complete corn-soybean meal-based basal diet with 0, 10, 20, 30 or 40% of EECM (Table 1). The diets were formulated to meet NRC (1994) nutrient requirements. The EECM was obtained from Viterra Canola Processing, Ste. Agathe, Manitoba. The 5 experimental diets were fed to the 40 groups (8 groups per diet) of birds from day 1 to day 21 of age. During the experimental period, feed and water were offered for ad libitum intake, and the feed consumption and body weight of the birds were monitored weekly for calculation of body weight gain, voluntary feed intake and feed conversion ratio. On the last day of the study, 1 bird from each cage was randomly selected, weighed and euthanized by cervical dislocation. Blood samples were immediately obtained from the euthanized birds via heart (when it was still pumping) puncture into vacutainer tubes (BD Vactainer®, Becton Dickinson & Co, Franklin Lakes, NJ) for determination of hematocrit and blood hemoglobin content. The thyroid glands, livers and kidneys were also obtained from the euthanized birds and weighed.

Diet and EECM samples were analyzed for dry matter (DM) and crude protein (CP) (N * 6.25) and amino acids. The EECM sample was further analyzed for glucosinolates content. The DM, CP and amino acids were analyzed using procedures that have previously been described by Woyengo et al. (2010). The glucosinolates composition of EECM was determined by gas chromatography (POS Pilot Plant Corp, Saskatoon, Saskatchewan, Canada) as described by Daun and McGregor (1981). Blood hematocrit was determined in a micro-capillary centrifuge. Blood hemoglobin content was determined by a hemoglobinometer (K2 6047 Coulter Hemoglobinometer, Coulter Diagnostics, Hialeah, FL). Data were subjected to analysis of variance using the GLM procedure (SAS software release 9.1, SAS Inst., Inc., Cary, NC) in a completely randomized design. Linear and quadratic contrasts for equally spaced levels were performed to assess the effect of increasing dietary level of the EECM.

RESULTS AND DISCUSSION

The EECM contained (% of DM) 37.8% crude protein, 0.74% methionine, 2.14% lysine, 1.62% threonine, 1.61% valine, 1.23% isoleucine, 2.57% leucine, 1.41% phenylalanine, 2.12% arginine, 0.97% histidine and 8.03 μmol/g of glucosinolates (data not shown). The total glucosinolates content in the EECM used in the present study was lower than the values reported by Seneviratne et al. (2010; 14.2 μmol/g), but higher than the values reported by Spragg and Mailer (2007; 5.26 μmol/g) for EECM. Dietary EECM linearly reduced ($P < 0.001$) body weight gain of birds (Table 2), which could partly have been due to reduced ($P < 0.001$) feed intake (Table 2). Glucosinolates and sinapine that are present in canola meal can reduce voluntary feed intake (Tripathi and Mishra, 2007). The reduced body weight EECM could also have partly been due to increased liver and kidney metabolic activities as evidenced by the increase in liver and kidney sizes due to EECM. The increased metabolic activities in liver and kidney results in increased utilization of various nutrients for maintenance at the expense of tissue deposition (Bauman et al., 1988), leading to reduced growth performance. Newkirk and Classen (2002) similarly reported reduced body weight of broilers due to dietary SECM.

Dietary EECM linearly increased ($P < 0.001$) liver weight relative to the live body weight (Table 2), which could have been due to increased activity of detoxification enzymes as a result of absorption of gut microbial degradation products of glucosinolates. Glucosinolate degradation products are toxic and increase the activity of hepatic detoxification enzymes, leading to increased liver size (Tanii et al., 2008). Dietary EECM quadratically increased kidney weight relative live body weight ($P = 0.020$), which could also have been due to increased activity of detoxification enzymes by the glucosinolate degradation products. Dietary EECM tended to increase ($P = 0.069$) heart weight relative to live body weight, which is indicative of chronic heart failure due to EECM. However, EECM did not affect the size of thyroid gland, and blood haemoglobin and hematocrit, implying that glucosinolates in the EECM neither interfered with thyroid function nor caused anemia.

In conclusion, dietary EECM reduced broiler growth performance and may adversely interfere with liver and kidney functions in broilers likely due to increased dietary concentration of glucosinolates. Therefore, the amount of EECM included in broiler diets should be based on the desired growth performance and the cost of the EECM.

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Table 1. Ingredient and nutrient composition of experimental diets (as fed)

	Dietary expeller-extracted canola meal (EECM) inclusion level, %				
Item	0	10	20	30	40
Corn	49.12	47.91	46.66	45.52	44.00
Soybean meal	41.00	32.60	24.20	15.70	7.50
EECM	0.00	10.00	20.00	30.00	40.00
Canola oil	5.00	4.77	4.56	4.34	4.18
Limestone	1.57	1.47	1.35	1.27	1.18
Monocalcium phosphate	1.50	1.45	1.45	1.40	1.36
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Mineral premix	0.50	0.50	0.50	0.50	0.50
L-lysine. HCL	0.03	0.07	0.11	0.15	0.18
DL-methionine	0.19	0.17	0.14	0.12	0.10
Threonine	0.09	0.06	0.03	0.00	0.00
Calculated composition					
ME, kcal/kg	3000	3000	3000	3000	3000
Crude protein, %	22.2	22.2	22.2	22.2	22.2
SID Lysine, %	1.22	1.22	1.22	1.22	1.22
SID Methionine, %	0.50	0.50	0.50	0.50	0.50
Analyzed crude protein	22.7	22.6	22.8	22.3	22.3

Table 2. Effect of inclusion level of expeller extracted canola meal (EECM) in diets on growth performance of broilers from hatch to 21 days of age, and on the thyroid gland, liver, kidney and heart weights relative to live body weight (BW) at 21 days of age

Item	Dietary EECM inclusion level, %					SEM	P-values	
	0	10	20	30	40		Linear	Quadratic
Feed intake, g/bird	1039	986	916	904	842	36.0	<0.001	0.776
BW[1] gain, g/bird	834	782	701	657	598	29.8	<0.001	0.844
FCR, g/g	1.25	1.26	1.31	1.38	1.41	0.03	<0.001	0.620
Thyroid gland, mg/g BW	0.07	0.13	0.09	0.08	0.13	0.02	0.423	0.859
Liver, mg/g BW	22.8	23.2	26.8	26.4	31.6	1.2	<0.001	0.231
Kidney, mg/g BW	6.6	6.2	6.1	6.2	7.7	0.5	0.143	0.020
Heart, mg/g BW	6.5	6.4	7.2	8.3	7.0	0.5	0.069	0.284