Original research article

Effects of derived meals from juncea (Brassica juncea), yellow and black seeded canola (Brassica napus) and multicarbohydrase enzymes supplementation on apparent metabolizable energy in broiler chickens

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ABSTRACT

Two experiments were conducted to determine the nitrogen-corrected apparent metabolizable energy (AMEn) of differently processed meals from Juncea (Brassica juncea), yellow and black seeded canola (Brassica napus), with or without supplementation of multi-carbohydrase enzymes (Enz) in diets for broiler chickens. The first experiment was a 3 × 2 factorial arrangement with the main factors being seed type (yellow [Yellow] or black [B1] canola seeds and Juncea seeds), processed at two temperatures (high temperature desolventized-toasted [HTDT] at 95 °C or low temperature desolventized-toasted [LTD] at 57 °C), with or without Enz. In Exp. 1, a total of 384 one-day-old male broiler chicks were randomly assigned to 64 battery cages, with 6 birds/cage. The second experiment was a 2 × 2 factorial arrangement with the main factors being seed type (Yellow or black [B2]), seed source (Scott, Saskatchewan or Truro, Nova Scotia) and Enz (with or without) supplementation. A total of 264 one-day-old male broiler chicks were randomly assigned to 44 battery cages, with 6 birds per cage. In Exp. 1 and 2, all birds were fed a common starter diet from 1 to 14 days of age. From d 15 to 21, the birds were fed one of the test treatments, a basal grower diet or the basal grower diet replaced with 30% test ingredient with celite (0.8%) added as an inert marker. Excreta was collected on d 20 and 21. In Exp. 1, there were no interactions (P > 0.05) among seed type, processing temperature and Enz. Processing temperature and dietary Enz did not affect (P > 0.05) AMEn of different canola meals. The AMEn of prepress solvent extracted canola and juncea meals (PSEM) from Yellow (11.2 MJ/kg) was higher (P < 0.05) than B1 (10.2 MJ/kg) and Juncea (10.2 MJ/kg). In Exp. 2, there were no interactions (P > 0.05) among seed color, location and Enz. Supplementation of dietary Enz did not affect (P > 0.05) AMEn of different cold press canola meals. The AMEn of cold press canola meals (CPM) from Yellow (14.7 MJ/kg) was higher (P < 0.05) compared with B2 (12.2 MJ/kg). In conclusion, among the different processing methods of oil extraction, meals derived from yellow seeded canola had higher AMEn than B seeded canola and Juncea.

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1. Introduction

In Canada, commercial canola meal (CM) is made from the mixtures of seeds of Brassica napus and Brassica rapa processed by expeller and solvent extraction processes (Canola Council of Canada, 2009). Canola meal is a good source of protein (35% to 38% crude protein on dry matter basis), and has a well-balanced amino acid composition (Newkirk et al., 2003). The most important anti-nutritional factors in CM are non-starch polysaccharides (NSP) and phytates (Simbaya et al., 1996). Currently, Canadian canola meal
contains very limited amounts of glucosinolates (4.2 μmol/g) (Canola meal feeding guide, 2015). Development of yellow-seeded canola was one of the major approaches to reduce the fiber content, increase the protein content and to enhance the overall nutritional characteristics of CM (Khajali and Slominski, 2012).

The processing of canola seed for separation of oil has a significant effect on oilseed meal quality (Mustafa et al., 2000; Newkirk et al., 1997, 2003). Commercial canola meal prepared by prepress solvent extraction process is exposed to 95 to 115°C during the processing which leads to losses in amino acid content and also reduced digestibility of amino acids (Anderson-Hafermann et al., 1993; Newkirk et al., 2003) and metabolizable energy content (Canola Council of Canada, 2009) when fed to poultry.

Another method of oil extraction is the cold press method, where, there is no pre-heating the seed and during extraction, there is not application of steam, which results in 50% to 70% oil extraction (Leming and Lember, 2005; Spragg and Mailer, 2007). Cold press cake is the main co-product of cold pressing extraction of oil which has high residual oil levels. Cold press cake is ground into a meal (CPM) prior to dietary addition. The residual oil in CPM ranges from 12% to 17% (Ferchau, 2000), which results in higher dietary energy (Seneviratne et al., 2010; Woyengo et al., 2010).

Dietary supplementation of cell wall degrading enzymes has proven to be beneficial for poultry in utilizing the polysaccharides in canola meal (Slominski and Campbell, 1990). The effect of different processing conditions and multicarbohydrase enzyme supplementation on apparent metabolizable energy (AMEn) in meals derived from yellow and black seeded canola and juncea in broiler chickens has not been adequately studied. This study was conducted to determine the AMEn in different prepress solvent extracted canola and juncea meals (PSEM) and CPM and evaluate the effects of multicarbohydrase supplementation to these meals on AMEn for broiler chickens.

2. Materials and methods

The experiments were conducted at Atlantic Poultry Research Centre, Nova Scotia (NS), Canada. The experimental protocol was reviewed and approved by the Animal Care and Use Committee of the Faculty of Agriculture, Dalhousie University. Birds were cared for according to the guidelines of Canadian Council of Animal Care (CCAC, 2009).

2.1. Preparation of prepress solvent extracted canola meals

Seeds from yellow seeded canola (line YN01-429) (Yellow) and commercial black canola (B1) grown near Scott, Saskatchewan (SK) and juncea seed grown in Saskatoon, SK, from the crop year 2007, were processed by prepress solvent extraction by the POS pilot plant, Saskatoon, SK. Canola and juncea meals were subjected to different temperatures during the desolvenization-toasting stage of processing. The normal processing temperature (95°C) (HTDT) was relative to low temperature processing (57°C) (LTDT). All seeds were processed at the same location within the same week.

2.2. Preparation of cold press canola meals

Yellow (line YN01-429) and black canola seeds (line N89-53) (B2) from Scott, SK or Truro, NS were single pressed at temperature ≤ 50°C in an oil expeller (Komet press, type DBS-1G Oeko Tec, IBG Monforts, Germany) by the Prince Edward Island Food Technology Centre. All seeds were processed during the same week. Press cakes produced were ground through a hammer mill, through a screen size 3 mm to produce CPM prior to incorporation into diets.

2.3. Experiment procedure

In Exp. 1, PSEM of Yellow and B1 canola and juncea with or without dietary enzymes were tested using 384 one-day-old male Ross 508 broiler chickens. Birds were randomly distributed to 64 battery cages (5 replicate cages per test diet and 4 replicate cages per basal diet) with 6 birds per cage. Reduced replicates for the basal diet were due to limitation in cages on the battery caging system. In Exp. 2, 2,264 one-day-old broiler chickens of the same strain used in Exp. 1 were used to evaluate CPM from Yellow or Black 2 canola seeds with or without dietary enzymes. Birds were randomly distributed to 44 battery cages (5 replicate cages per test diet and 4 cages per basal diet) with 6 birds per cage. In both experiments the multicarbohydrase enzyme cocktail contained cellulase (≥2,800 U/g), amylase (≥2,500 U/g), mannanase (≥400 U/g), galactonase (≥50 U/g), xylanase (≥1,000 U/g), gluconase (≥600 U/g), and protease (≥200 U/g) prepared and provided by the Department of Animal Sciences, University of Manitoba. The starter diet, formulated to contain 23% crude protein and 3,050 kcal/kg ME was fed from 1 to 14 days of age to all birds; a basal grower diet, formulated to contain 20% crude protein and 3,150 kcal/kg ME (Table 1). The starter and basal grower diets met or exceeded the nutritional requirements of broiler chickens (National Research Council (NRC), 1994). In the grower diet, celite (Hyflo Super Cell, food chemical codex grade) was added at 0.8% as an inert marker to determine digestibility using the indicator method (Leeson and Summers, 2001). From 15 to 21 days of age, the birds were fed either the basal grower diet or the test diet (basal grower diet replaced by 30% of one of the test ingredients). On d 20 and 21, a representative sample of excreta was collected from the trays underneath each cage.

Table 1 Composition (as fed basis) and calculated nutrient content of the broiler starter diet and basal grower diet.

| Item                     | Starter | Grower |
|--------------------------|---------|--------|
| Ingredients, g/kg        |         |        |
| Corn                     | 448     | 507    |
| Soybean meal             | 380     | 301    |
| Wheat                    | 100     | 100    |
| Poultry fat              | 33      | 46     |
| Limestone, ground        | 16      | 18     |
| Metaphosphoric acid      | 9.0     | 8.0    |
| Vitamin-mineral premix   | 5.0     | 5.0    |
| Celite                   | 0.0     | 8.0    |
| Iodized salt             | 4.0     | 4.0    |
| Methionine premix        | 4.5     | 2.2    |
| Cobain                   | 0.5     | 0.5    |
| Stafac 441               | 0.25    | 0.25   |
| Total                    | 1,000   | 1,000  |
| Calculated analyses, g/kg|         |        |
| Metabolizable energy, MJ/kg| 12.8 | 13.2  |
| Crude protein            | 230     | 200    |
| Ether extract            | 53      | 67     |
| Crude fiber              | 26      | 25     |
| Calcium                  | 10      | 9.2    |
| Available phosphorus     | 4.5     | 4.0    |
| Lysine                   | 7.5     | 7.5    |
| Methionine + cystine     | 5.5     | 5.5    |

1. Premix supplied the following per kilogram of diet: vitamin A 9,750 IU; vitamin D 32,000 IU; vitamin E 25 IU; vitamin K3 mg; vitamin B7 27.6 mg; calcium pantothenate 11.5 mg; vitamin B6 2.0 mg; niacin 29.7 mg; folic acid 1 mg; choline chloride 800 mg; biotin 30 mg; vitamin B1 4.95 mg; thiamin 3 mg; manganese oxide 70.2 mg; zinc oxide 80 mg; copper sulfate 25 mg; selenium premix 0.1485 mg; ethoxyquin 50 mg; wheat middlings 1.543 g; ground limestone 190 mg.

2. Hyflo Super Cel, food chemical codex grade (Van Waters and Rogers Ltd, Richmond, BC, Canada).

3. Supplied per kg premix: DL-methionine, 0.5 kg; wheat middlings, 0.5 kg.

4. Monensin (coccidiostat) 200 g/kg (Pfizer Animal Health, London, ON, Canada).

5. Virginiamycin (Antibiotic) 44 g/kg (Phibro Animal Health, Regina, SK, Canada).
and immediately frozen. Excreta samples were frozen at −20°C until analyzed. Feed samples were retained for subsequent analysis.

In both experiments, diet mixing was done using a paddle type Hobart mixer. All diets in mash form were fed ad libitum to birds from a trough attached to the front of the cage. Feed intake and body weights of the birds were recorded on d 0, 14 and 21 for both experiments. Water was provided ad libitum from nipple drinkers. Throughout the trials, mortality was recorded when it occurred and birds were examined post-mortem by a veterinary pathologist.

2.4. Chemical analyses

The dry matter (DM) content of feed and excreta was determined using method 935.29 (AOAC, 2005). Feed samples were weighed (approximately 30 g) in duplicate and placed in a standardized hot air oven at 52°C for 24 h and then weighed to calculate DM%. Frozen (−20°C) excreta samples were weighed (approximately 30 g) in duplicate, freeze-dried and then weighed to calculate DM%. Oven-dried feed and freeze-dried excreta samples were ground to pass through a 1 mm screen prior to conducting analysis. Gross energy (GE) was determined using a Parr adiabatic bomb calorimeter (Parr Instrument Company, Moline, Illinois). Nitrogen content of dried feed and excreta samples were determined in duplicate using a Leco Nitrogen analyzer (Leco corporation, St Joseph, MI) method 990.03 (Association of Official Analytical Chemists (AOAC), 2005). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) of the test ingredients were determined using ANKOM analyzer (AOAC, 2005; Komarek, 1993). The ether extract (EE) was determined according to AOAC using petroleum ether as the solvent (2005). Acid insoluble ash (AIA) procedure was performed using 4 mol/L HCl method (McCarthy et al., 1974).

2.5. Calculation of apparent energy digestibility coefficient (AED) and AMEn

The apparent digestibility coefficients (ADC) of gross energy in the basal and test diets were calculated using the following equation, ADC = 100 − [100 × (% AIA in diet/ % AIA in excreta) × (% GE in excreta/ % GE in diet)]. The resulting ADC for gross energy in the diets was used to calculate ADC in the test ingredients, according to the formula of Sugiuira et al. (1998). The AMEn of the test diets and test ingredients were calculated using the substitution method described by Leeson and Summers (2001). Nitrogen correction was calculated by using the correction factor of 8.22. The equation used to calculate AME and AMEn are as follows:

AME = GE_{diet} − \left(\frac{GE_{excreta} \times AIA_{diet}}{AIA_{excreta}}\right).

AMEn = GE_{diet} − \left(\frac{GE_{excreta} \times AIA_{diet}}{AIA_{excreta}}\right) − 8.22 \times N_{\text{retained}},

where GE diet and GE excreta (kcal/kg) equal to the GE of the diet and excreta, respectively; AIA diet and AIA excreta (%) equal to acid insoluble ash in the diet and excreta, respectively; 8.22 is energy value (kcal/kg) of uric acid; and N retained (g/kg) is the N retained by the broilers per kilogram of diet consumed. The retained nitrogen was calculated as follows:

N_{\text{retained}} = N_{\text{diet}} − \left(\frac{N_{\text{excreta}} \times AIA_{\text{diet}}}{AIA_{\text{excreta}}}\right),

where N_{\text{diet}} and N_{\text{excreta}} (%) equal to N contents of the diet and excreta, respectively.

The AMEn of the test ingredient was calculated as follows:

AMEn of the test ingredient = AMEn of the basal diet − [(AMEn of the basal diet − AMEn of the test diet) / 0.3].

2.6. Statistical analysis

The two experiments were analyzed by ANOVA using the mixed model procedure of SAS (SAS/STAT Version 9.3, SAS Institute Inc., Cary, NC). For Exp. 1, ANOVA determined the differences among seeds (S), processing (P) and enzyme (Enz) supplementation and interactions among them. For Exp. 2, ANOVA determined the differences among seeds, seed source (Location) and Enz supplementation and interactions among them. If significant main effects or interactions were found, the Tukey–Kramer test was used to compare differences among the least square means at α = 0.05 (Montgomery, 2005). The results presented are least square means and standard error of mean (SEM).

3. Results

3.1. Chemical composition of different meals derived from juncea, yellow and black seeded canola

Dry matter and chemical composition of meals derived from pre-press solvent extraction and cold-press extraction methods (Table 2) indicated meals derived from yellow seeded (Yellow) B. napus contained more CP and less NDF than meals derived from black seeded canola. The EE of all PSEM were less than 20 g/kg. Neutral detergent fiber and ADF of Yellow canola meals were less than B1 canola and Juncea meals. The CP content of CPM varied from 347 to 380 g/kg, on DM basis. The EE of Yellow meals (264 and 233 g/kg) from seeds grown at Scott and Truro, respectively) were higher than Black 2 meals from seeds grown at Scott (181 g/kg) and Truro (180 g/kg). The NDF and ADF content of yellow meals were 37% and 45%, respectively, lower than Black 2 meals.

In both experiments, all diets were well received by the birds. No differences in feed intake occurred among diets fed containing the different test ingredients.

3.2. Experiment 1

In Exp. 1, there were no interactions (P > 0.05) among seed type, processing and multicrohodase supplementation on AED, AME and AMEn (Table 3). The AED, AME and AMEn of PSEM from Yellow canola were higher (P < 0.05) than those from B1 canola and Juncea. In PSEM, method of processing (HTDT and LTDT) and enzyme supplementation did not affect (P > 0.05) AED, AME and AMEn of the meals.

3.3. Experiment 2

In Exp. 2, there were no interactions (P > 0.05) among seed type, seed source and multicrohodase supplementation on AED, AME and AMEn (Table 4). The AED, AME and AMEn of CPM from Yellow canola were higher (P < 0.05) than those from Black 2. There was no difference in AMEn between CPM derived from seeds grown at Scott (SK) and Truro (NS) (Table 4). Enzyme supplementation did not affect (P > 0.05) AMEn of CPM.

4. Discussion

In both, pre-press solvent extraction and cold press processing methods, meals derived from yellow B. napus contained more
**Table 2**

Chemical composition of different meals derived from yellow and black seeded canola and juncea (on DM basis).

| Item | Crude protein, g/kg | Gross energy, MJ/kg | Ether extract, g/kg | Neutral detergent fiber, g/kg | Acid detergent fiber, g/kg | Ash, g/kg |
|------|---------------------|---------------------|--------------------|-------------------------------|--------------------------|-----------|
| Prepress solvent extracted canola meals |                   |                     |                    |                               |                         |           |
| High temperature (95°C) desolventized-toasted | |                         |                    |                               |                         |           |
| Yellow seeded canola | 445 | 18.1 | 19.6 | 150 | 120 | 60 |
| Black seeded canola | 422 | 18.2 | 18.1 | 205 | 174 | 64 |
| Juncea | 454 | 17.8 | 14.9 | 176 | 135 | 64 |
| Low temperature (57°C) desolventized-toasted | |                         |                    |                               |                         |           |
| Yellow seeded canola | 456 | 18.2 | 13.3 | 173 | 124 | 61 |
| Black seeded canola | 421 | 17.8 | 17.4 | 211 | 186 | 64 |
| Juncea | 449 | 18.0 | 19.0 | 195 | 139 | 63 |

Cold press canola meals

| Item | Crude protein, g/kg | Gross energy, MJ/kg | Ether extract, g/kg | Neutral detergent fiber, g/kg | Acid detergent fiber, g/kg | Ash, g/kg |
|------|---------------------|---------------------|--------------------|-------------------------------|--------------------------|-----------|
| Yellow seeded canola | 355 | 24.5 | 264 | 92 | 74 | 47 |
| Black seeded canola | 380 | 23.1 | 181 | 150 | 120 | 47 |
| Yellow seeded canola | 347 | 23.3 | 233 | 120 | 92 | 58 |
| Black seeded canola | 364 | 22.6 | 180 | 198 | 171 | 56 |

1 Seed source: yellow Brassica napus (line YN01-429) grown in Scott, SK, Canada.
2 Seed source: black B. napus (line N89-53) grown in Saskatoon, SK, Canada.
3 Seed source: black B. napus (line unknown) grown in Scott, SK, Canada.
4 Seed source: yellow B. napus (line YN01-429) and black Brassica napus (N89-53) grown in Truro, NS, Canada.

**Table 3**

Apparent energy digestibility coefficient (AED), apparent metabolizable energy (AME, MJ/kg) and apparent metabolizable energy (AMEn, MJ/kg) of meals derived from juncea (Brassica juncea), yellow and black seeded canola (Brassica napus) processed at different temperatures during desolventizing-toasting process.

| Item | Seeded canola (S) | SEM | P-value | Processing (P) | SEM | P-value | Enzyme (E) | SEM | P-value | S × P × E |
|------|-------------------|-----|---------|---------------|-----|---------|------------|-----|---------|-----------|
| AED | 0.71 | 0.64 | 0.62 | 1.35 | <0.001 | 0.66 | 0.66 | 1.00 | 0.986 | 0.66 | 0.65 | 1.09 | 0.552 | 0.855 |
| AME, MJ/kg | 12.7 | 11.6 | 11.5 | 0.24 | 0.001 | 12.0 | 11.8 | 0.20 | 0.451 | 12.0 | 11.8 | 0.20 | 0.426 | 0.563 |
| AMEn, MJ/kg | 11.2 | 10.2 | 10.2 | 0.21 | 0.002 | 10.6 | 10.4 | 0.20 | 0.376 | 10.7 | 10.4 | 0.22 | 0.240 | 0.537 |

HTDT = high temperature (95°C) desolventized-toasted; LTDT = low temperature (57°C) desolventized-toasted.
1 Prepress solvent extracted meals (PSEM) derived from yellow Brassica napus (line YN01-429) grown in Scott, SK, Canada.
2 PSEM derived from Black B. napus (line N89-53) (source: unknown).
3 PSEM derived from Juncea B. juncea grown in Saskatoon, SK, Canada.
4 Standard error of mean that applies to the statistical model.
5 + and – indicate diets supplemented with and without multicalbohydrase enzymes, respectively.

**Table 4**

Apparent energy digestibility coefficient (AED), apparent metabolizable energy (AME, MJ/kg) and apparent metabolizable energy (AMEn, MJ/kg) of meals derived from yellow and black seeded canola (Brassica napus) from different locations processed by cold press oil extraction.

| Item | Seeded canola (S) | SEM | P-value | Seed source (L) | SEM | P-value | Enzyme (E) | SEM | P-value | S × L × E |
|------|-------------------|-----|---------|-----------------|-----|---------|------------|-----|---------|-----------|
| AED | 0.67 | 0.61 | 1.88 | 0.032 | 1.49 | 11.31 | 13.7 | 13.7 | 13.2 | 0.39 | 0.307 | 0.819 |
| AME, MJ/kg | 15.6 | 13.5 | 0.44 | 0.002 | 14.9 | 14.1 | 14.8 | 14.2 | 0.44 | 0.378 | 0.931 |
| AMEn, MJ/kg | 14.7 | 12.2 | 0.39 | <0.001 | 13.7 | 13.1 | 13.7 | 13.7 | 0.39 | 0.307 | 0.819 |

1 Cold press meal (CPM) derived from yellow Brassica napus (line YN01-429).
2 CPM derived from Black B. napus.
3 Standard error of mean that applies to the statistical model.
4 Seed source: Scott, SK, Canada.
5 Seed source: Truro, NS, Canada.
6 + and – indicate diets supplemented with and without multicalbohydrase enzymes, respectively.

Protein and less fiber than black canolas, which is in agreement with the previous studies (Montoya and Leterme, 2009; Simbaya et al., 1995; Slominski et al., 1994, 2011). The fiber content of Yellow (NDF 150 g/kg; ADF 120 g/kg) were found to be less than B1 (NDF 205 g/kg; ADF 174 g/kg) and Juncea meals (NDF 176 g/kg; ADF 135 g/kg). This agrees with the previous work (Bell and Shires, 1982; Montoya and Leterme, 2009; Simbaya et al., 1995; Slominski et al., 2011) stating that yellow rapeseed canola meal contained lower fiber content than B canola. The lower fiber content of yellow B. napus meals could be due to thinner hulls in seeds compared to those used to produce black B. napus meals (Simbaya et al., 1995).

The fiber content (NDF and ADF) of yellow CPM was lower than black CPM. The fat content in B2 was comparable to Australian CPM (181 versus 197 g/kg) reported by Geier (2004). The fat content in Yellow were 28% higher than B2 meals. The level of residual oil measured as EE ranging from 180 to 264 g/kg were higher than expected. A residual oil of this magnitude would reduce the saleable low temperature oil available for the crusher, using cold pressing. The higher residual oil in the CPM is due in part to the lack of added heat during processing. Leaving more oil in the meals would result in increased energy value of the press cakes but could contribute to more difficult handling and stability.

The AED of PSEM from Yellow was higher than B1 and Juncea, which is in consistent with previous studies (Simbaya et al., 1995; Slominski et al., 1999). High fiber content interferes with digestibility and lowers ME value of the CM in broiler chickens (Slominski and Campbell, 1990). The AME and AMEn contents of PSEM derived from Yellow canola (11.2 MJ/kg) were higher than...
Black 1 canola (10.2 MJ/kg) and Juncea (10.2 MJ/kg) meals. The AME and AMEn of PSEM from Yellow and B1 canola meals was found to be higher than previous reports (8.8 MJ/kg), Emamzadeh et al., 2008; (8.3 MJ/kg), Lee et al. (1995) (8.9 MJ/kg), Newkirk et al. 2003. Slominski et al. (2011) reported that the AMEn of Juncea, yellow and black canola were 1,736 kcal/kg (7.3 MJ/kg), 2,190 kcal/kg (9.2 MJ/kg) and 1,904 kcal/kg (8.0 MJ/kg), respectively. The differences in AMEn of CM in broiler chickens could be due to the nutritive composition of oilseed meals, especially the amount of residual oil left in the meal. Reduction of desolventizer-toaster temperature from HTDT to LTDT did not affect AMEn of meals. Toasting canola meals remove remnants of hexane and inactivate some of the anti-nutritional factors after processing (Newkirk and Classen, 2002), while excessive toasting would lead to browning of CM, which is an indication of Maillard reaction, perhaps denaturing the protein. During the prepress solvent extraction process of oil extraction, the cooking phase temperature was the same (60 ± 5°C in the top tray and 90 ± 5°C in the bottom tray) for both HTDT and LTDT meals. During desolventization and toasting process, the temperature in HTDT meal processing was 95 ± 5°C (both top and bottom trays) and the temperature in LTDT meal processing was 57 ± 5°C (both trays). By altering temperature processing conditions, the meal quality can be either increased or decreased (Anderson-Hafermann et al., 1993). A minimum amount of heat (90°C) is applied to deactivate myrosinase enzyme, to avoid break down of glucosinolates to aglucones, toxic metabolite for animals. Thirty to seventy percent of Glucosinolates are thermally degraded during canola crushing process (Khajali and Slominski, 2012). High temperature during oil extraction process, could result in losses in content and digestibility of amino acids, particularly lysine (Khajali and Slominski, 2012). In this study, different processing conditions did not affect AMEn of canola meals. Changes in the desolventizer-toaster temperatures may not have been large enough to decrease the AMEn of the meal.

In this study, supplementation of multicalbohydrase did not influence AMEn of PSEM or CPM. These findings agree with other studies, where the addition of multicalbohydrase enzyme to the diet did not affect ME content in CM based diets (Simbaya et al., 1996; Mushtaq et al., 2007). Similarly, Meng and Slominski (2005) reported that multi-carbohydrase supplementation in corn diet did not affect ME content in CM based diets (Simbaya et al., 1996; Mushtaq et al., 2007). In this study, supplementation of multicalbohydrase did not influence AMEn of PSEM or CPM. These findings agree with other studies, where the addition of multicalbohydrase enzyme to the diet did not affect ME content in CM based diets (Simbaya et al., 1996; Mushtaq et al., 2007). Similarly, Meng and Slominski (2005) reported that multi-carbohydrase supplementation in corn diet did not affect ME content in CM based diets (Simbaya et al., 1996; Mushtaq et al., 2007).

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