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The effect of canola meal processing by heat, moisture and ammonium bicarbonate on metabolisable energy and nitrogen retention in broiler chicken

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Abstract

Nutritional value of canola meal can be improved by processing methods. In this experiment factorial arrangement of processing factors, including three levels of heat exposure (60, 90 & 120 °C), two levels of time (15 & 30 min.), two levels of moisture (wet & dry) and two levels of ammonium bicarbonate (0 & 3%) were considered. Twenty-four kinds of processed canola meal with 3 replicates were fed to 18 days old broilers (70% basal diet plus 30% processed canola meal) with row canola meal as a control group. At 21 days of age, samples of feed and feces were collected to measure the gross energy and nitrogen content. Apparent metabolisable energy of canola meal and nitrogen retention is calculated by marker assay method. Acid insoluble ash was used as indigestible marker. Results showed that N retention negatively affected as the temperature rises. Ammonium bicarbonate increased the apparent metabolizable energy of canola meal and nitrogen retention at P=0.06. In conclusion, to improving the apparent metabolizable energy and N retention, the best combination of factors was 60 °C heat exposure for 30 min and wet treatment without ammonium bicarbonate.

Keywords: canola meal, processing, heat, ammonium bicarbonate

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Introduction

Canola meal (CM) is a byproduct of oil industry containing high level of crude protein and lower gross energy as compared to soybean meal (Bell, 1993). Canola is the genetically improved rapeseed that contains less than two percent erucic acid and 30 micromoles per gram glucosinolates of seed dry matter after oil extraction. The breeding programs aimed to produce the cultivars of canola in which anti-nutrients materials such as glucoseinolate, sinapin and fiber are as low as possible (Mailer et al., 2008). Inclusion of high levels of CM in broiler diet significantly depress feed consumption and growth performance accompanied by decreased metabolizable energy (Lee et all., 1991; Leeson et all., 1987). The maximum inclusion rate of canola meal in broiler diet varies (10 -25%) due to different nutritional property of the CM samples (Naseem et al., 2006). The commercial desolventization and toasting procedure have been said to be the reason for variability of nutritional value of CM (Newkirk et al., 2003). Some authors (Perez-Maldonado et al., 2002) stated that maximum 200 and 300 g/kg of CM (solvent extracted or extruded) may be used in broiler diets for starter and finisher phase, respectively. Currently CM cannot be replaced completely for soybean meal in broiler diets due to low apparent metabolisable energy (AME) and other anti-nutrients. There are processing techniques to improve nutritional value of CM. It is shown that ammoniation process may increase AME value of rapeseed meal (Paik et al., 1991) while Keith and Bell (1982) reported that ammoniation combined with steam treatment may reduce AME in pig. In addition, heat treatment reduced nitrogen solubility of different meals as well as emulsifying and foaming properties of the CM (Khattab and Arntfield, 2009). The time and level of heat used for treatment are important elements affecting the final quality of the CM. It has been reported that crude protein losses induced by heating is reduced in the feeds with moisture higher than 19% (Wang et al., 2000). Current information does not point out the best combination of different treatment procedures by which CM quality would be comparable with the soybean meal or the same feedstuff. The objective of the present experiment was to find out the best combination of heat exposure level and exposing time with or without ammoniation and moisture treatment on the AME and nitrogen retention of CM in broiler chickens.

Material and Methods

Experimental diets and birds

One batch of commercial CM was purchased from Gorgan province, Iran and was treated before being fed to the chicks. Treatments were factorial combination of three levels of heat (60, 90 & 120 °C), two levels of ammonium bicarbonate (0 & 3%) and two levels of moisture (wet & moist). Every combination of treatments was exposed to heat for 15 and 30 minutes. To apply moist treatment, 200 ml water was added per each kilogram of CM and mixed homogeneously. Heat treatment was exerted using an automated oven. In total, 24 different treated CM were acquired as test ingredients (TI) and used for metabolic assay. A basal

Table 1: Basal diet composition used for metabolic assay

Ingredient	Corn	Corn	$CaCO_3$	Di-Calcium	Salt	Min-Vit	Inert	lysine
Percent %	69	23.8	2.38	1.49	0.750	0.5	2	0.078

Table 2. Simple effects of temperature, moist and ammonium bicarbonate on AME content of test diet, treated CM and nitrogen retention

		AME (Test diet)	AME (Canola)	N Retention
Temperature (°C)	60	2438.31	1974.17	0.77^{a}
	90	2293.28	1829.14	0.72^{ab}
	120	2182.73	1718.59	0.70^{b}
Moisture	dry	2261.49	1797.34	0.71
	wet	2348.07	1883.92	0.75
Ammonium bicarbonate (%)	0	2166.92	1702.77	0.71
	3	2442.64	1978.49	0.75
N		72	72	72
Pooled SEM		77.07	77.07	0.01
P-values				
Temperature		0.36	0.36	0.05
Moist		0.55	0.55	0.10
Ammonium		0.06	0.06	0.06
Temperature × Time		0.48	0.48	0.15
Temperature × Moist		0.32	0.32	0.78
Temperature × Ammonium		0.15	0.15	0.68
Temperature × Time × Moist		0.07	0.07	0.05
Temperature × Time × Ammonium		0.53	0.53	0.64
Moist × Ammonium		0.10	0.10	0.14

Means with different superscript are significantly vary ($P < 0.05$)

diet (BD) is formulated with corn gluten as a very digestible protein source to minimize the interference in protein digestion with test ingredients (Table 1).

Twenty six dietary treatments consisted of basal diet, control diet (70% basal diet + 30% non-treated CM) and 24 test diets (TD), each containing 70% basal diet and 30% treated CM. All dietary treatments were subjected to AME determination assay. A total of 300 day old male chicks were reared until 17 d with a commercial diet. Thereafter, 234 chicks have been divided in 78 cages, each containing 3 birds. Experimental diets (test diets), control diet and basal diet were offered to the chicks from 17 days of age, each replicated three times (total of nine chicks). Fresh droppings of every cage were collected at the ages of 21 to 23 d. Diets and excreta samples were analysed for dry matter, acid insoluble ash (AIA), GE by adiabatic calorimetric bomb (IKA C 200 bomb calorimeter), and N content using semi-automated Kjeldal apparatus (FOSS TECATOR, 2400 Kjeltec Analyzer Unit). The AIA was considered as the indigestible marker and measured according to the references (Vogtmann et al., 1975). AME of the test diets was calculated based on the formula used by (Scott et al., 1998) as shown below

$$AME = GE_{diet} - (GE_{excreta} \times Marker_{diet} / Marker_{excreta})$$

The AME value of treated and non-treated CM were calculated by difference methods (Ning et al. 2014) as shown in below;

$$AME_{TI} = [(AME_{TD} - AME_{BD} \times (1 - C_{test})]/C_{test}$$

Where C_{test} is the substitution ratio of test ingredients.The below formula was used to calculate nitrogen retention (Driver et al., 2006) .

Apparent nitrogen retention = 100-[100× (% AIA_{feed}/% $AIA_{excreta}$) × (%$N_{excreta}$/%N_{feed})

Results and Discussion

Simple effects of treatment factors on AME content of test diets, CM and N retention are shown in Table 2. Increasing the heat level, negatively affected the N retention ($P < 0.05$) while AME content of test diets and CM were not affected. Dietary lysine content and protein solubility of the diet can be reduced significantly by high temperature above 100 °C (Wang et al., 2000). This is the reason for low digestibility and retention of N in heated CM. Furthermore, it is shown that when the diet moisture is more than 19.05%, there is least dietary protein loss (Wang et al., 2000) and there is significant interaction between temperature and time. Conversely, we observed no interaction between temperature and time. The glucoseinolate level of CM is diminished by toasting method but digestible amino acids level in non-heated CMis higher than heated CM (Newkirk et al., 2003). These findings are consistent with the current result. Principally, high temperature reduced the dry matter digestibility. For instance, It has been reported that autoclaved barley had reduced dietary dry matter digestibility (Herstad and McNab, 1975).

Reduction of glucosinolates and lysine content of diet by ammoniation process have been reported earlier (Bell et al., 1984). This may lead to better AME content and protein digestibility of the feed. In the current experiment ammoniation process increased AME content and N retention at $P = 0.06$, indicating the beneficial effects of ammoniation method to some extent. Nevertheless, ammoniation is the cause of less dietary protein quality (Keith and Bell, 1984). Hence, using this processing method is not recommended for the feed ingredient containing high quality protein such as soybean meal.

The interaction between temperature, time and moisture on N retention were significant ($P < 0.05$) on N retention (Table 3). At 60 °C temperature and 30 min time, dry treatment caused significantly lower N retention as compared to the wet treatment. This result is in agreement with the previous report (Wang et al., 2000). However, as the temperature increase the effect of moisture in reducing protein loss vanished. It can be concluded that at lower heating rate, moisture is beneficial. In the current experiment, the highest N retention achieved by 60°C temperature, 30 min. time and wet treatment while the lowest N retention was detected at 120°C temperature, 30 min. time and dry treatment. The interaction between temperature, time and moisture on energy digestibility showed a trend ($P = 0.07$), demonstrating relatively effectiveness of treatments on AME. The effects of moist heating on the reduction of glucosinolate have been documented earlier (Schone et al., 1996).

As shown in Figures 1-3, none of the treatments resulted in significant difference of AME content and nitrogen retention as compared with control diet. The highest AME were observed in T7 (60 °C, 30 min, wet

Table 3. The effects of temperature × moist ×time on AME content of test diet, canola meal and nitrogen retention

Temperature (°C)	Time	Moist	AME (Test diet)	AME (Canola meal)	N retention
60	15	dry	2384.42	1920.28	0.77^{ab}
60	15	wet	2482.13	2017.99	0.76^{ab}
60	30	dry	2093.54	1629.39	0.71^{b}
60	30	wet	2793.17	2329.03	0.84^{a}
90	15	dry	2479.88	2015.74	0.72^{b}
90	15	wet	2245.13	1780.98	0.74^{b}
90	30	dry	2167.19	1703.04	0.69^{bc}
90	30	wet	2280.93	1816.79	0.74^{ab}
120	15	dry	2702.31	2238.17	0.78^{ab}
120	15	wet	2037.96	1573.82	0.71^{b}
120	30	dry	1741.58	1277.43	0.59^{c}
120	30	wet	2249.08	1784.93	0.71^{bc}

Means with different superscript are significantly vary ($P < 0.05$)

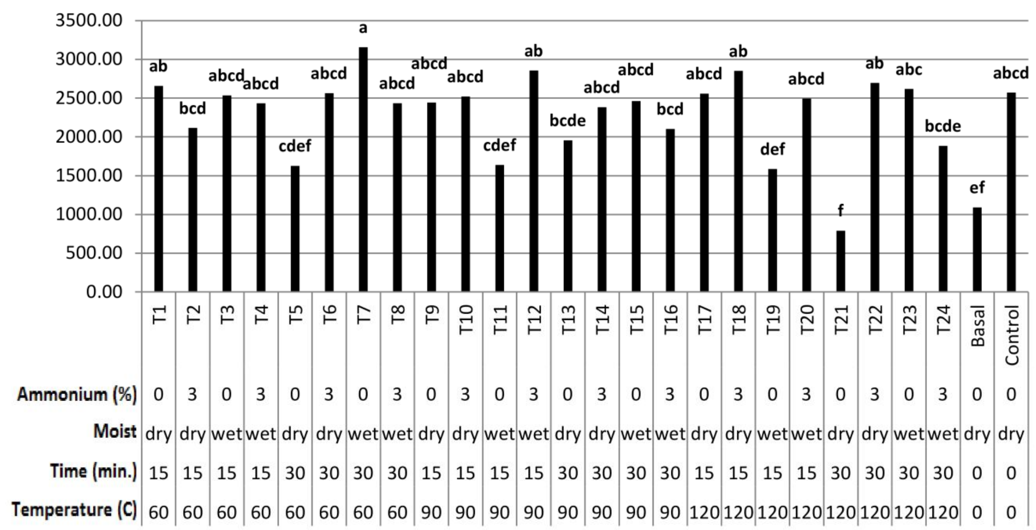

Figure 1: The comparision between AME content of test diets, basal diet and control

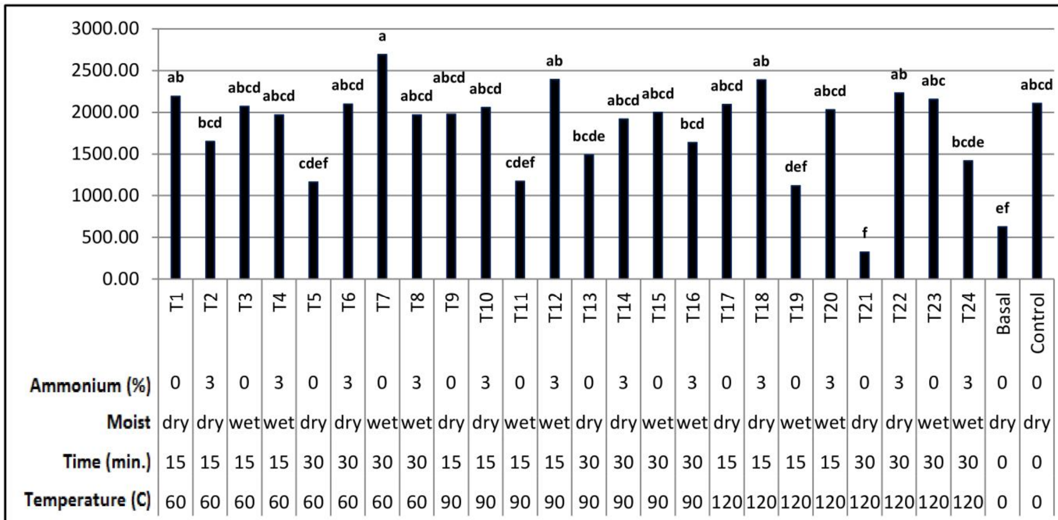

Figure 2: The comparision between AME content of test ingredients (canola meal), basal diet and control

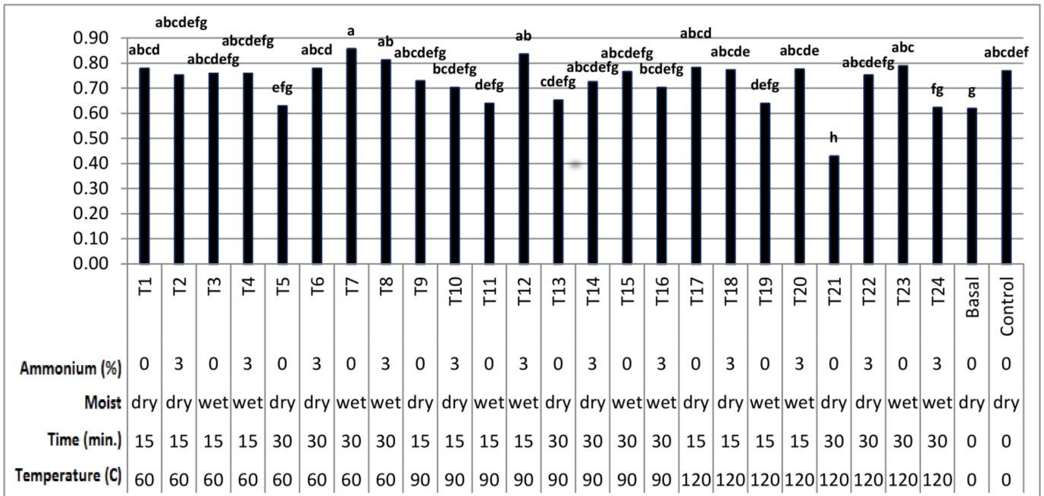

Figure 3: The comparossion between nitrogen retention rate of test diets, basal diet and control

with no ammonium), while the lowest AME belonged to T21 (120 °C, 30 min, dry with no ammonium) that is significantly ($P < 0.05$) lower than control. Similarly, the highest and lowest N retention were observed in T7 and T21 respectively

Conclusion

To maximize AME and N retention in canola meal processing, the best level of heating treatment is 60°C for 30 minutes with wet treatment. Likewise, previous reports, high temperature are so harmful on N retention. Ammoniation process is effective to increase AME into some extent.

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