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Short Communication

True and Apparent Metabolizable Energy of Crude Glycerin in Betong Chicken

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ABSTRACT

An experiment was conducted to determine the nitrogen-corrected true and apparent metabolizable energy (TMEn and AMEn, respectively) of crude glycerin (CG) for Betong chicken using a precision-fed rooster assay. A total of 15 male Betong chickens were assigned to three groups (0, 10, and 15% CG) of the experimental diet. Based on this experiment, CG supplementation enhanced the GE, TMEn, and AMEn of an experimental diet as the CG level was escalated. The TMEn and AMEn of CG were 3138 and 3046 kcal kg^{-1} at 15% and 2977 and 2896 kcal kg^{-1} at 10%, respectively.

Keywords: Apparent metabolizable energy, Betong chicken, crude glycerin

INTRODUCTION

Thailand, which is the second largest biodiesel producers in Asia, produced approximately 1420 million liters in 2017. The country was expected to increase the biodiesel consumption in the next 4 years to up to 5.97 million liters/day (Sutabutr, 2012). Crude glycerin (CG) is the main by-product of this biodiesel production, derived from approximately 10% of the total feedstock. However, this by-product contains approximately 50 to 90% glycerol and 15 to 35% of impurities such as methanol or ethanol, fatty acids, water, and some chemical compounds generated by transesterification (Dozier et al., 2008; Jung & Batal, 2011). Thus, the demand for CG is still limited because of the impurities and costly process for medium- and small-scale producers to upgrade the quality, although it can be used in the food, pharmaceutical, and animal feed industries (Thompson & He, 2006).

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Literature reports indicate that CG contains various gross energy (GE) of approximately 3173 to 6021 kcal/kg depending on the process and composition (Dozier, Kerr, & Branton, 2011; Thompson & He, 2006). Up to the present time, studies on CG have been primarily oriented towards investigating its effect on poultry performance, meat quality, and egg traits. These studies have revealed that the optimum range of CG inclusion is 5 to 10% of the total feed for broilers, laying hens, and quails (Erol, Yalcin, Midilli, & Yalcin, 2009; McLea, Ball, Kilpatrick, & Elliott, 2011; Németh, Zsédely, & Schmidt, 2013). Recently, CG nitrogen-corrected apparent metabolizable energy (AMEn) content of GE approximates 62.3 to 98.7% for broiler chickens (Dozier et al., 2011) and 97.6% for laying hens (Németh et al., 2013). Other studies indicate that the use of CG in livestock production is determined by the type of animal, age, and amount of glycerin in the diet (Cerrate et al., 2006). As the chickens in the previous studies have been genetically selected, they are assumed to have an improved feed digesting ability. Consequently, the generated energy values might be overestimated for local chickens. However, to the best of our knowledge, this hypothesis has not been reported. Therefore, the aim of this study was to determine the nitrogen-corrected true metabolizable energy (TMEn) and AMEn of CG in Betong chickens.

MATERIALS AND METHODS

Materials and Chemical Analysis

CG was obtained from the Specialized Research and Development Center for Alternative Energy from Palm Oil and Oil Crops, Prince of Songkla University (PSU). Three replicate CG samples were analyzed for moisture, crude protein, crude fat, and ash (Association of Official Agricultural Chemists [AOAC], 2000). Glycerol and the GE were determined using high-performance liquid chromatography (HPLC) (Hu, Luo, Wan, & Li, 2012) and an isoperibol calorimeter (LECO AC500), respectively. Table 1 shows the composition of the CG investigated in this study.

Table 1
Crude glycerin composition in the experimental feed

Item	Value
Moisture, %	15.96
CP, %	0.64
Crude fat, %	15.08
Ash, %	6.34
Gross energy (kcal/kg)	4472
Glycerol (%)	42.88
MONG[1]	34.82

[1]MONG: matter organic non-glycerol. Defined as 100-[glycerol content (%) + water content (%) + ash content (%)]

Birds and Housing

All experimental procedures were approved by the ethical principles of Prince of Songkla University. Fifteen 22-week-old male Betong chickens from the poultry farm of the Faculty of Natural Resources, PSU were sorted by body weight (1.77 ± 0.11 kg) and randomly placed in individual metabolic cages (50 × 43 × 60 cm dimension) with individual feeders and water bottle nipples inside an evaporative housing system. During the experiment, the temperature was maintained at 25 to 28°C with 16-h lighting. The roosters were adapted to the cage for 7 days prior to the experiment with ad libitum access to water and commercial layer feed.

Feeding Treatment

The experimental diets consisted of three levels of CG supplementation (0, 10, and 15%) in ground corn as the basal diet. The roosters were assigned to three groups with five replications for each treatment. In addition, the true metabolizable energy (TME) was determined using the method of Sibbald (1986). Briefly, all chickens were fasted for 24 h and then the excreta was collected for the next 24 h to calculate the endogenous energy loss. After a 4-day recovery period given ad libitum feed, the chickens were crop intubated with 30 g of the experimental diets following a 24-h fast. Water was provided all the time of the experiments. The excreta was collected using the harness technique and tray under the cages to examine feed regurgitation. The excreta samples were weighed, oven-dried (60°C for 72 h), ground, and pooled for each treatment prior to analyzing the dry matter (DM), total nitrogen (Kjeldahl method), and GE (LECO AC500) using benzoic acid as a standard.

Calculations and Statistical Analysis

The DM digestibility, AMEn, and TMEn of experimental feed were calculated based on the methods of Dozier et al. (2011) and Parsons, Potter and Bliss (1982), respectively. Data from the experiments were analyzed as a completely randomized design. The significant differences subjected to further analysis with Tukey using SPSS version 16.0.

RESULTS AND DISCUSSION

In CG suplemented diet, the values of TMEn, AMEn and GE were increased (Table 2). It is believed to be caused by energy contribution from crude glycerin which carries high gross energy content. The result was found linear with dry matter digestibility which is numerically higher than that of the controlled diet. High absorption rates of glycerin were related to its small molecular weight and passively absorbed in the gut (Guyton, 1991). The enzyme glycerol kinase metabolized glycerol to glyceraldehyde-3-phosphate, was then used for fatty acid synthesis, gluconeogenesis or oxidized via the glycolytic pathway (Robergs & Griffin, 1998). However, such enzyme may be saturated in a high level of CG and as a result, decrease the metabolizable energy value (McLea et al., 2011).

As shown in Table 3, TMEn and AMEn values in 15% level inclusion of CG were higher than those in 10% inclusion. These results indicate that CG metabolizable energy may depend on its level in the diets. Nevertheless, the chickens are able to

Table 2
Dry matter digestibility (%) and energy values (kcal/kg) of experimental feed

Energy value	Crude glycerin			*P value*
	0%	10%	15%	
GE	3994 ± 32[a]	4199 ± 26[b]	4349 ± 62[c]	0.000
AMEn[1]	3214 ± 62[a]	3354 ± 120[a]	3565 ± 105[b]	0.001
TMEn[2]	3320 ± 65[a]	3447 ± 122[a]	3672 ± 104[b]	0.001
DM Digestibility[3] (%)	87.38 ± 0.54	87.49 ± 2.37	88.14 ± 3.58	0.890

[a,b] Means within the same row with different superscripts differ significantly ($p < 0.05$).
[1] AMEn = GE I - GE O - 8.22 NF/FI, where GE I = gross energy intake; GE O = gross energy output; NF = nitrogen retained in the fed bird, FI = feed intake and 8.22 = nitrogen correction factor reported by Hill and Anderson (1958).
[2] TMEn = (FEF - (EEF + 8.22 NF) + (EEU + 8.22 NU)/FI, where FEF = The feed gross energy; EEF = The excreta gross energy from the fed bird; EEU = The excreta gross energy from the fasted bird; NU = Nitrogen retained in the fasted bird; NF and FI as stated above.
[3] Digestibility (%) = (FI-E+E Endogenous/FI) x 100, where E = The fed bird excreta in dry matter; and E Endogenous = The fasted bird excreta in dry matter.

Table 3
Energy values of crude glycerin (kcal/kg)

Energy value	Crude glycerin		*P value*
	10%	15%	
GE	4472 ± 126		
AMEn[1]	2896 ± 104[a]	3046 ± 90[b]	0.040
TMEn[2]	2977 ± 106[a]	3138 ± 89[b]	0.031
% of GE[3]	66.56 ± 2.36[a]	70.18 ± 1.98[b]	0.031

[a,b] Means within the same row with different superscripts differ significantly ($p < 0.05$).
[1] AMEn = Total AMEn intake- Basal AMEn/Glycerin intake
[2] TMEn = Total TMEn intake- Basal TMEn/Glycerin intake
[3] % of GE = TMEn/GE *100%

metabolize CG up to 15%. It is difficult to compare with another study due to limited research in CG utilization for local chicken. Jung and Batal (2011) found that TMEn of CG was varied from 80 to 99% of GE. However, the TMEn content in this study was 66.56 and 70.18%. Meanwhile, the AMEn values of crude glycerin were 64.7 and 68.1% of GE for 10 and 15% levels of inclusion, respectively. The results were close to Dozier et al. (2011) who observed crude glycerin from various sources, including poultry fat (51.54% glycerol) and yellow grease (52.79% glycerol) with 62.29 and 68.68% AMEn values of its gross energy. In contrast, McLea et al. (2011) evaluated crude glycerin (81% glycerol) with broiler chicken. They found that the AMEn value was 75% of gross energy. Németh et al. (2013) reported a higher AMEn value (97.6% of GE) when conducted the experiment using laying hen and crude glycerin from rapeseed oil (86.8% glycerol).

The differences in the AMEn and TMEn values are believed to be related to different breed, age and sources of CG. Different from Betong chickens, commercial chickens in other studies are genetically selected to optimize the feed utilization. Furthermore, the digestion ability is also influnced by increased ages. This is due to its well-developed gastrointestinal tract. Another factor needs consideration is the quality of CG. Low glycerol level (42.88%) and high crude fat (15.08%) in the present study lead to higher GE (4472 kcal kg^{-1}) than that pure glycerol (4325 kcal kg^{-1}) reported by Dozier et al. (2011). Accordingly, Jung and Batal (2011) found a correlation between crude fat with GE in crude glycerin. The authors concluded that the higher the fat level, the higher GE and the lower glycerol content it would be.

The lower AMEn percentage is due to the representation of the fatty acid in the MONG content. This finding has confirmed the work of Dozier et al. (2011) who reported a reduced AMEn due to its relatively high fatty acid content. Wiseman and Blanch (1994) also found a negative correlation between free fatty acid (FFA) content and AMEn value in young and adult broiler chicken fed with coconut and palm kernel oil. Moreover, inadequate ratio between monoglycerides and FFA which is due to the lack of triglycerides tended to reduce bile secretion. This may result in lower absorption rates compared to oil and fat sources with triglycerides and FFA in the intestine (Sklan, 1979).

CONCLUSION

Based on this study, it could be concluded that the DM digestibility, AMEn and TMEn values of CG were affected by its level in the experimental feed. The CG inclusion in the diet up to 15% was well utilized by the Betong chicken. The TMEn and AMEn of CG were 3138 and 3046 kcal kg^{-1} at 15% and 2977 and 2896 kcal kg^{-1} at 10%, respectively.

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