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Effects of feeding crude glycerin on feedlot performance and carcass characteristics in finishing goats

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ABSTRACT

Twenty-four crossbred male (Thai Native × Anglo Nubian) weaned goats (17.4 ± 2.8 kg of initial BW) were used to assess the effect of the dietary supplementation of crude glycerin (CG) for corn grain on performance, carcass traits, muscle chemical composition, fatty acid profile, and blood metabolites. Four isocaloric and isonitrogenous diets were offered to the experimental animals (6 goats per treatment) for 91 days using randomized completely block design. The goats individually received dietary treatments containing 0, 5, 10, and 20% of CG (87.61% pure) on a DM basis. The diets were offered ad libitum as total mixed rations twice daily. Weight gain and concentrations of blood metabolites were determined. At the end of the experimental period, the harvest data and carcass characteristics of the goats were recorded, and muscular *longissimus dorsi* (LD) composition was determined. No significant effect of CG inclusion was observed in any of the growth performance, carcass, and meat quality traits studied. Likewise, mean serum glucose and BHBA concentrations were not affected ($P > 0.05$) by dietary treatments whereas serum insulin concentration linearly increased (L, $P = 0.02$) with increasing the amount of CGLY supplementation. Also, no apparent effects on FA composition were detected, except for C15:0, C16:0, C16:1, and C22:5n-3 were affected ($P < 0.05$) by CG level. We conclude that crude glycerin can be used as substitution for corn grain up to the level of approximately 20% of dry matter in the diets of finishing goats, and this study was a good approach in exploiting the use of biodiesel production for goat production.

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1. Introduction

As feed costs have recently increased, alternative feed sources, such as glycerin (rich in glycerol), have become a major focus for the livestock industry. Crude glycerin (CG) is a by-product of biodiesel production resulting from the formation of methyl esters of fatty acids from triglycerides (Dasari et al., 2005), and has been evaluated as a potential feed ingredient for livestock in many species including poultry (Min et al., 2010), swine (Schieck et al., 2010), cattle (Mach et al., 2009; Parsons et al., 2009), and sheep (Gunn et al., 2010a,b; Avila-Stagno et al., 2013).

In ruminants, different quantities of glycerin are either converted to volatile fatty acids, particularly propionate and butyrate at the expense of acetate or are directly absorbed from the digestive system and act as a precursor for gluconeogenesis in the liver (Rémond et al., 1993; Krehbiel, 2008) and can provide energy for cellular metabolism (Goff and Horst, 2001). CG is an appealing byproduct in feedlot diets because it is hypothesized that

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CG is primarily converted to propionate in the rumen, thus acting as a precursor for glucose synthesis. Researchers reported that 35–69% of the crude glycerol administered was used to produce propionate (Rémond et al., 1993). If crude glycerol increased propionate concentration, an increased gain-to-feed (GF) would be expected. However, GF responses have been contradictory. Feeding glycerin may also improve feed digestibility and growth performance of cattle in adose-dependent manner (Wang et al., 2009). The potential value of crude glycerin as a major component of the diet has been reported in beef cattle (Pyatt et al., 2007; Mach et al., 2009; Parsons et al., 2009) and dairy cows (Carvalho et al., 2011), and inclusions of 10–20% in diet DM have been used without negatively affecting lamb performance (Gunn et al., 2010a,b). However, to our knowledge, there is little information available on feeding rates and production responses in goats fed moderate to high amounts of glycerin regarding the effects of this by-product on goat performance, and carcass characteristics. Therefore, the objective of this study was to determine the effects of feeding different concentrate CG amounts, as an energetic ingredient, on performance, carcass characteristics, meat quality, and blood metabolites of finishing goats.

2. Materials and methods

The experiment was conducted at the Small Ruminant Research Center, Faculty of Natural Resources, Prince of Songkla University located in Songkhla Province, Thailand, over a period of 105 days, with 14 days for animal adaptation to diets and daily management and 91 days for data collection. All procedures involving animals were approved by the Ethical Principles for the Use of Animals for Scientific Purposes of the National Research Council of Thailand (NRCT) for the metabolism study and finishing study.

2.1. Animals, design and experimental diets

Twenty-four crossbred male (Thai Native × Anglo Nubian) growing goats (17.4 ± 2.8 kg of initial BW) were stratified and blocked by BW in a randomized complete block design. Goats were randomly assigned within block to 1 of 4 treatments (6 goats/treatment), and were adapted to the experimental diets for 2 weeks before the beginning of data collection. Goats were housed individually in ventilated pens (1.0 m × 1.0 m) with wooden slotted flooring in an open goat barn raised above the ground where water and mineral salt were available at all times.

The 4 corn-based dietary treatments consisted of 0, 5, 10, and 20% of crude glycerin (on DM basis) and were formulated to be isonitrogenous and isocaloric (DM basis) and to meet or exceed the NRC (1981) requirements of fattening goats. The CG was produced in palm-diesel facility (New Biodiesel, Surat Thani Province, Thailand) and contained 87.61% of glycerin, 8.07% of water, 1.24% of sodium, and 0.64% of methanol. Palm-derived glycerin from single batch was added to the total mixed rations (TMR) as liquid. The ingredients and determined chemical composition of the components of each diet are presented in Table 1.

Feed was offered for ad libitum consumption twice daily in two equal portions at 08:00 and 16:00 h for 91 days. The amount of TMR offered and refused was recorded daily for each goat and the offered amount was adjusted to ensure approximately 10% of refusals after feeding. Feed refusals were weighed daily, analyzed for DM, recorded, and discarded to calculate DMI, accurately. Individual feed ingredient was analyzed weekly for DM to adjust the diet composition for ingredient moisture content. Composite feed samples were collected weekly and dried in a forced-air oven at 60 °C for 48 h for analysis of DM. Dried samples were ground to pass a 1-mm screen (Cyclotech Mill, Tecator) and then analyzed for DM, CP, ether extract, ash (AOAC, 1995). The tests for the evaluation of neutral detergent fiber and acid detergent fiber were determined according to Van Soest et al. (1991). Non-fibrous carbohydrate (% in the DM) was calculated as (Mertens, 1997): 100 − (CP + NDF + ether extract + ash).

2.2. Animal performance, slaughter and sample collection

All goats were weighed before the morning feeding at the beginning of the experiment for every 2 weeks at the same time of day and before transportation to the abattoir of the Institute of Animal Science (final weight) thereafter. Daily DMI by each goat was estimated by summing the weekly intake and dividing by the number of days of the week. The ADG was determined by dividing BW gain (initial full BW − final full BW) by the number of days in the study. Feed conversion was calculated as the ratio between ADG and DMI (g of BW gain/g of DMI).

At the end of the 91-days experiment, three blocks would be randomly selected (which each block would compose of all treatments) for slaughter after being fasted overnight. Therefore the total number of goats for this carcass study was 12 (3 goats per treatment). The animals were slaughtered according to the standard slaughter procedures described in Thai Agricultural Standard TAS 6006 (2008). Fasted live and hot carcass weights were recorded before and immediately after slaughter, respectively. Directly after slaughter, noncarcass components (skin, head, feet, lung, heart, liver, spleen, kidneys, kidney fat, and gastro-intestinal tract fat) were removed and weighed. The stomach (rumen, reticulum, omasum, and abomasum) and postruminal tract (small intestine, large intestine, and caecum) were removed and weighed separately. The contents of the stomach and postruminal tract were removed, washed, and weighed to obtain the weight of the empty stomach and postruminal tract. The carcass yield percentage was calculated as 100 (hot carcass weight/slaughter weight). Carcasses were chilled overnight at 4 °C and cold carcass weight was determined the next morning. Carcass length and width were measured. The carcasses were split longitudinally in two parts. The right sides of the carcasses were cut into eight pieces (loin, hind leg, chump, rack, should, fore leg, breast, and neck) according to Thai Agricultural Standard TAS 6006 (2008) and were weighed, separately. Individual parts were then dissected into lean meat, bone, trimmings and weighed, separately. The muscular *longissimus dorsi* (LD) area was made on the left cut surface (of the chilled carcass) between rib 12 and 13. The LD (the section between the last lumbar and the first sacral vertebrae) was collected. These cuts of meat and two per animal were labeled and frozen immediately after collection for later measurement of the fatty acid profile, chemical composition, meat color and shear force characteristics.

2.3. Laboratory analyses

Samples of feed and LD muscle were subjected to proximate analysis following the standard methods of AOAC (1995). Dry matter (DM) was determined by oven drying in a forced air oven at 105 °C for 24 h. The N content of feed and LD muscle was determined using a Kjeltec Auto Analyzer (Tecator, Hoganas, Sweden), while ether extract (EE) was determined in petroleum ether using a Soxtec Auto Analyzer (Tecator). The ash content was determined by ashing the samples in a muffle furnace at 550 °C for 5 h. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin concentrations were determined by methods of Van Soest et al. (1991). NDF was analyzed without α-amylase, and the value of NDF and ADF were expressed inclusive of residual ash. Lignin was obtained by treatment of ADF residue with 72% sulfuric acid (Van Soest et al., 1991).

Muscle surface color was measured objectively using a HunterLab Miniscan Plus Spectrocolorimeter on the same cut surface the LD. Instrumental color measurements were recorded for L^* (measures darkness to lightness; lower L^* indicates a dark color), a^* (measures redness; higher a^* value indicates a reddish color), and b^* (measures yellowness; higher b^* value indicates a yellowish color) at 3 locations of exposed lean to obtain a representative reading. To determine shear force, samples were defrosted at room temperature until their internal temperature reached 2–5 °C. After weighing, samples were trimmed, and thin sections from the lateral and extremities were removed; 4 samples, parallel to the muscle fibers and having 1 cm of thickness and 5 cm of length were obtained, to measure the shear force in a texture analyzer (TA-XT*Plus*-Texture Analyzer, with a Warner-Bratzler Blade probe, Texture Expert Exponent-Stable Micro Systems Software, Ltd. in Godalming, Surrey, UK. SMS). For each sample, 6 shear force results were obtained.

2.4. Fatty acids profile analysis

Fatty acids were extracted and methylated from the meat using methods described by Hara and Radin (1978). After extraction and methylation, each sample was injected (1 ml) into a Finnigan GC Focus gas

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