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Evaluating the performance, carcass traits and conjugated linoleic acid content in muscle and adipose tissues of Black Bengal goats fed soybean oil and sunflower oil

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ABSTRACT

An experiment was conducted to investigate the feeding of soybean oil (SOY) and sunflower oil (SUN) on performance, carcass traits and fatty acid (FA) composition, including conjugated linoleic acids (CLA) in meat of Black Bengal goats. Eighteen growing goats (initial body weight (BW) of 11.1 ± 0.49 kg and 9–12 months of age) were equally allotted into 3 groups (control, SOY and SUN) in a randomized complete block design (blocked according to initial BW). Goats were fed concentrate mixtures with similar nitrogen and calculated metabolizable energy content with added vegetable oils (SOY or SUN) at 45 g/kg dietary dry matter or without oil (control), and berseem hay (60:40). A metabolic trial was conducted after 105 days of feeding, and carcass traits and fatty acid composition of longissimus dorsi muscle and subcutaneous adipose tissues were determined at 122 days of feeding. Oil supplementation did not affect ($P>0.05$) average daily gains and feed intake in goats. Digestibilities of nutrients except ether extract (EE), and intake, excretion and balance of nitrogen were also similar ($P>0.05$) among dietary treatments. Digestibility of EE in goats receiving both plant oils was higher ($P<0.01$) than control. Feeding of oils did not affect ($P>0.05$) carcass traits, and percentages of protein, fat and ash in muscle. While supplementing oils did not change ($P>0.05$) the proportion of total saturated FA, they lowered several medium-chain FA in muscle and adipose tissues. However, the proportion of total polyunsaturated FA (PUFA; $P<0.001$) and CLA *cis*-9, *trans*-11 ($P<0.001$) in these tissues were highest in SUN, followed by SOY, and control. Oils had no effect ($P>0.05$) on concentrations of serum glucose, cholesterol and protein, but increased ($P<0.05$) serum triglyceride concentration compared with control. In conclusion, feeding of SOY and SUN at a concentration of 45 g/kg of total diets did not affect digestibility and performance, but increased the PUFA and CLA content in muscle and adipose tissues in Black Bengal goats with the greatest effect noted for SUN.

1. Introduction

Growing awareness of the relationship between diet and health among consumers has increased demands of foods containing functional micro-components that may help in maintaining health and preventing diseases (Scollan et al., 2006). In ruminant derived milk, meat and their products, the functional bioactive fatty acids (FA) include n-3 polyunsaturated fatty

Abbreviations: ADF, acid detergent fiber; ADG, average daily gain; BW, body weight; CLA, conjugated linoleic acid; CON, control; CP, crude protein; DM, dry matter; EE, ether extract; FA, fatty acid; FCR, feed conversion ratio; MUFA, mono-unsaturated fatty acids; NDF, neutral detergent fiber; PUFA, poly-unsaturated fatty acids; SEM, standard error of mean; SFA, saturated fatty acids; SOY, soybean oil; SUN, sunflower oil; VA, vaccenic acid.

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acids (PUFA) and conjugated linoleic acids (CLA), particularly *cis*-9, *trans*-11 CLA, which confer a number of potential health benefits (Benjamin and Spener, 2009). Therefore, many researchers have investigated a number of strategies including feed formulations and nutritional management to enrich CLA and n-3 PUFA in meat and milk from ruminant sources (Duckett and Gillis, 2010; Lock and Bauman, 2004; Shingfield et al., 2013).

The CLA are produced in the rumen during biohydrogenation of linoleic acid (Lock and Bauman, 2004). They are also produced in tissues via desaturation of vaccenic acid (*trans*-11 C18:1; VA), another intermediate of biohydrogenation of oleic, linoleic and linolenic acid (Griinari et al., 2000; Mosley et al., 2002). Corl et al. (2001) observed that a proportion of 0.78 of total *cis*-9, *trans*-11 CLA in milk fat is originated from desaturation of VA by Δ^9-desaturase. Various efforts had been attempted to increase CLA content in ruminant tissues, which involved increasing the availability of precursors of CLA in the rumen by feeding linoleic and linolenic acid rich oils and oil seeds (Lock and Bauman, 2004), and/or modulating rumen microorganisms and metabolism responsible for biohydrogenation of PUFA, CLA and VA to stearic acid by phytochemicals (Lourenco et al., 2010; Patra, 2011; Patra and Saxena, 2011).

Composition of diets fed to ruminants influences the FA, including CLA, composition of meat and milk (Lock and Bauman, 2004; Smith et al., 2009). Indeed, feeding of oils and oil seeds rich in linoleic and linolenic acids increased CLA and VA content in tissues of lambs (Boles et al., 2005; Bolte et al., 2002), beef cattle (Noci et al., 2007), milk fat in dairy cattle, sheep and goats (Bouattour et al., 2008; Bu et al., 2007; Gómez-Cortés et al., 2008; Li et al., 2009; Shingfield et al., 2006), but to a different extent depending upon the source of oils (Duckett and Gillis, 2010). However, the influence of oils on CLA and VA content in goat meat has not been reported to our knowledge of the literature. The information obtained from other animals may not be assumed for meat type goat breeds as genetics also play a likely role in determining FA including CLA content in tissues and milk due to variation in Δ^9-desaturase activity among breeds of animals (Smith et al., 2009; Soyeurt et al., 2008). For instance, the values of Δ^9-desaturase indices were lower for Jersey and Brown-Swiss cows than Holstein cows (Soyeurt et al., 2008). Black Bengal goats are reputed for their delicacy of meat, superior quality skin, high fecundity and fertility and adaptability, although their body weight (BW) growth rate, milk yield and mature body weight is low (Devendra and Burns, 1983). Sunflower oil (SUN) and soybean oil (SOY) are rich in linoleic acid, and they differ in this FA content, which may influence CLA composition in meat. Therefore, the objective of this study was to investigate the effects of SUN or SOY supplementation to the diets of meat type Black Bengal goats on performance, carcass characteristics and FA content of muscle and adipose tissues.

2. Materials and methods

2.1. Animal, diet and management

This study was conducted following the guidelines of Institutional Animal Ethics Committee. Eighteen Black Bengal wethers (9–12 months old) with mean body weight (BW) of 11.1 ± 0.49 kg were assigned to 6 blocks of 3 animals each, based on initial BW (each containing 3 nearly identical wethers) according to a randomized complete block design. Within each block, the animals were then randomly allocated to 3 groups. The goats were penned individually in a well-ventilated shed. The goats in control group (CON) received a diet consisted of a concentrate mixture (600 g/kg of dry matter (DM) intake) and berseem (*Trifolium alexandrinum*) hay (400 g/kg; DM basis) (Table 1) to meet the maintenance and growth (30 g/day) requirements (Mandal et al., 2005). This control diet was fed to all animals before the start of the experiment for 30 days. Goats in treatment groups were fed with either SOY or SUN at a rate of 67 g/kg of the concentrate mixture (as-fed basis), which supplied oil concentrations at 45 g/kg of the total dietary DM intake. Oils were first mixed with a small amount of the concentrate mixtures as a premix. These premixes were then mixed together with remaining amount of the concentrate mixtures for proper distribution of the oils. Each concentrate mixture was prepared for 7 days of feeding. The FA contents were high in oil added concentrate mixtures compared with the control. Concentrations of PUFA, C18:0 and C18:2 FA were substantially higher in the concentrate mixture of SUN than the concentrate mixture of SOY. This resulted from the higher content of C18:0, C18:2 and PUFA concentrations in SUN than SOY (Table 2). All the concentrates were formulated to contain similar crude protein, calculated metabolizable enegy, calcium, phosphorus, neutral detergent fiber (NDFom) and acid detergent fiber (ADFom). Concentrate mixtures and berseem hay were offered separately in two equal meals (09:00 and 15:30 h). Berseem hay was provied at 1.1 times the previous day's hay consumption. Goats had access to *ad libitum* clean drinking water twice daily. Amounts of feed offered and orts were recorded daily, and feeds were sampled weekely and composited for analysis of nutrient composition. Body weight was measured every 15 days throughout the growth study. Average daily gain (ADG) was determined by dividing the difference of the final and initial BW by the number of days in the study. The experimental feeding period lasted for 122 days.

2.2. Metabolism trial

After 105 days of experimental feeding, four goats that were assigned to four corresponding high BW blocks during growth trial were selecetd from each group according to a randomized complete block design, weighed and transferred to metabolism stalls having facilities for collection of feces and urine separately. Goats were fed with the same diets as consumed previously. Metabolism trial lasted for 9 days with 3 days of adaptation to the metabolism stalls, and 6 days of