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The effect of palm oil or canola oil on feedlot performance, plasma and tissue fatty acid profile and meat quality in goats

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ABSTRACT

Twenty-four entire male Kacang kid goats were fed diets containing 3% canola (n = 12) or palm oil (n = 12) supplements for 16 weeks. The goats had an initial live weight of 14.2 ± 1.46 kg and were fed a mixed ration *ad libitum* (10.4 MJ/ME and 14% crude protein). There was no difference in feedlot performance due to diet. Inclusion of canola oil reduced ($P<0.05$) kidney fat weight and increased ($P<0.05$) linolenic acid (18:3n − 3) concentration in the blood plasma, m. *longissimus lumborum* (LL), liver, and kidney. The palm oil diet increased ($P<0.05$) myristic (14:0) and palmitic (16:0) acid content in the blood, but this did not alter these fatty acids in the LL muscle. Lipid oxidative substances in the liver and LL from palm oil fed kids were higher ($P<0.05$) than those from canola supplemented kids. The incorporation of canola oil into the goats' diet increased muscle omega-3 fatty acid content, but lipid oxidation was lowered in the blood and muscle LL.

1. Introduction

Given meat is a source of fat in the human diet, especially saturated fatty acids, which are associated with coronary diseases (Daley, Abbott, Doyle, Nader, & Larson, 2010) many consumers have changed their meat consumption patterns. Consumers who suffer from coronary problems are advised to lower their saturated fat intake. The current western diet tends to contain 11–30 times more omega-6 fats than the omega-3 fats, which has been hypothesized as a significant factor for the rising rate of inflammatory disorders and obesity (Calder, 2004; Palmiquist, 1994; Simopoulos, 1999). Reducing the levels of omega-6 or increasing the omega-3 fats in animal diets will lead to muscles with more favorable n − 6 to n − 3 ratios (Givens, Kliem, & Gibbs, 2006) which may help to improve consumer health (Wood & Enser, 1997).

The addition of lipids to ruminant feed is a tool used when an increase in the energy density of the diet is desired without increasing the proportion of grains as a source of energy, since grains represent a more expensive fraction of the diet (Silva, Olivera, Barbosa, Garcez, & Bagaldo, 2011). The major sources of lipids with saturated fatty acids include palm oil, palm kernel oil, tallow and lard. Plant derived (canola, soybean, sunflower, flaxseed, linseed oil, etc.) and marine oils (salmon, menhaden, tuna, mackerel oil, etc.) are rich sources of polyunsaturated fatty acids (PUFA) (Wiseman, 1984). Of these oils canola has several beneficial health effects (McDonald, Gerrard, Bruce, & Corner, 1989). This oil also has a higher ratio of unsaturated fatty acids to saturated fatty acids compared with animal fats (Eskin & McDonald, 1991) and it increases the linolenic acid (18:3n − 3) distribution in the carcass increasing intramuscular fat leading to a pleasant flavor in the meat (Peraza-Mercado, Jaramillo-Lopez, del Hierro, & Alarcon-Rojo, 2006). Having said this subtle interactions between diet and animal gender have been found for organoleptic characteristics of lamb meat (Hopkins, Hall, Channon, & Holst, 2001) so this must be considered in experimental designs.

Goats are important meat-producing animals in the tropics (Almeida, Chwalbach, Waal, Greyling, & Cardoso, 2006; Phengvichith & Ledin, 2007) and factors such as slaughter age, breed, castration and nutrition can affect the quality characteristics of goat meat (Costa et al., 2010; Tshabalala, Strydom, Webb, & de Kock, 2003). The objective is to produce high quality goat carcasses with a high percentage of lean that also exhibit low levels of saturated fatty acids and high levels of omega-3 fatty acids (Pearce, Norman, & Hopkins, 2010). Previous work has indicated that a diet supplemented with sunflower oil did not significantly alter the carcass composition or meat quality of kid goats (Marinova, Banskalieva, Alexandrov, Tzvetkova, & Stanchev, 2001). However, we are unaware of any work which has studied the benefits of feeding canola oil supplemented diets to kids as opposed to the more traditional use of palm oil, given that production of canola oil has increased in the last decade and it is available at reasonable cost. As such the aim of this study was to evaluate the carcass composition and fatty acid profile of selected tissues of kid goats after a feeding period on two diets differing in fatty acid status.

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2. Materials and methods

2.1. Animal welfare

This study was undertaken following the guidelines of the Research policy on animal ethics of the Agriculture and Natural Resources Research Center, Iran.

2.2. Feeding phase

Twenty-four 6-month-old entire male native Kacang kid goats with an initial body weight (BW) of 14.2 ± 1.46 kg were assigned to two different diets in equal numbers using a completely randomized design and supplemented with either palm or canola oil. The rations were equivalent in metabolizable energy and protein being 10.4 MJ/kg DM intake and 14% on a dry matter basis respectively (NRC, 2007). The diets were based on 65% concentrates (including either 3% canola or 3% palm oil) and 35% roughage (Table 1). The rations were mixed and fed *ad libitum* with each goat penned separately. Fresh water was provided. The goats were allowed a 2 week adjustment period and were then fed for 16 weeks. Feed consumption was recorded weekly. The goats were weighed and blood samples were collected at the commencement of the experiment, day 33, day 66 and day 102 of the experimental period.

2.3. Slaughter and carcass measures

At the end of feeding period (16 weeks) all of the goats were slaughtered after an overnight fast (12 h). A commercial slaughter procedure was undertaken and the carcasses were weighed hot. Subsequently the pelt, head, feet, internal organs (lungs and trachea, liver, and kidney) and internal fat including peritoneal and mesenteric fats, kidney fat, channel fat and heart fat were weighed separately.

Table 1
Ingredient and chemical composition of experimental diets fed to goats.

Ingredient (as-fed)	Diets	
	Palm oil	Canola oil
Palm oil (%)	3.00	–
Canola oil (%)	–	3.00
Oil palm frond (%)	35	35
Palm kernel cake (%)	23	23
Soybean (%)	13.4	13.4
Corn grain milled (%)	10.5	10.5
Rice brain (%)	13.7	13.7
Limestone (DM) (%)	0.5	0.5
Salt (DM) (%)	0.4	0.4
Vitamin–mineral premix (DM) (%)	0.5	0.5
Chemical composition		
Dry matter (DM) (%)	92.3	92.2
Crude protein (%)	14.0	14.0
Metabolizable energy (MJ/kg DM)[1]	10.4	10.4
Ash (%)	8.44	8.45
Crude lipids (%)	4.26	4.27
Neutral detergent fiber (%)	49.5	49.3
Acid detergent fiber (%)	34.4	34.3
Fatty acids of diets (% of total fatty acids)		
C10:0	0.48	0.44
C12:0	2.13	2.16
C14:0	6.16	5.46
C15:0	1.72	1.34
C16:0	22.1	18.7
C16:1	0.25	0.29
C17:0	1.91	1.81
C18:0	4.32	4.46
C18:1n − 9	37.2	39.1
C18:2n − 6	20.6	23.4
C18:3n − 3	0.47	0.74
C20:4n − 6	0.22	0.41
Total saturation fatty acids (SFA)	39.7	34.7
Total unsaturated fatty acids (UFA)	60.2	65.1

Samples of the liver, kidney and heart were obtained within 1 h *post mortem* and frozen at −80 °C. Carcasses were chilled for 24 h at 2–3 °C and then re-weighed and split into two equal halves (left and right) using an electric saw. The right half carcass was weighed and cut into five primal cuts; neck, shoulder, breast-flank, loin and leg (Colomer-Rocher, Morand-Fehr, & Kirton, 1987). The cuts were weighed and expressed as a percentage of the total weight of the right half carcass. Each cut was dissected into lean meat, bone, subcutaneous fat and intermuscular fat. All meat quality measurements were made on the left half carcass.

2.4. Meat quality measures

The m. *longissimus lumborum* (LL) was removed between the 12th thoracic and 5th lumbar vertebrae from the left side of each carcass. The LL was divided randomly into 3 parts and each part was vacuum-packed and aged for 1, 7 or 14 days at 4 °C. At the end of *post mortem* aging time, all samples were frozen at −80 °C until subsequent determination of lipid oxidation or fatty acid composition within a period of one month. Lipid oxidation was evaluated using the thiobarbituric acid reactive substances (TBARS) method (Ke, Ackman, Linke, & Nash, 1977). The TBARS assay was performed as described by Buege and Aust (1978). Total fatty acids were extracted from 1 day aged meat samples using a chloroform–methanol solvent extraction system as described by Folch, Lees, and Stanley (1957). Briefly, 1 g of homogenized sample (LL muscle, liver or kidney) or 2 ml of blood plasma was added with 20 ml of chloroform:methanol 2:1 (v/v). A fixed amount of heneicosanoic acid (C21:0, Sigma Co., St Louis, MI, USA) was then added to the extract as an internal standard prior to drying under nitrogen. The fatty acid methyl ester (FAME) was prepared and stored in screw-capped Teflon lined vials at 4 °C for gas chromatography (Model 6890, Agilent Technologies, USA). The FAME was separated on a Supelco SP-2330 (Supelco, Inc., Bellefonte, PA, USA), fused silica capillary column (60 m, 0.25 mm ID, 0.20 Inc., Bellefonte, PA, USA) and fatty acids were identified as described by Karami, Alimon, Sazili, Goh, and Ivan (2011).

2.5. Data analysis

Data were analyzed using analysis of variance in a GLM procedure of SAS ver. 9.1 (SAS Institute Inc., Cary, N.C. 2003) with treatment (diet) as the fixed effect. For carcass compositional traits of half carcass weight was in included in the model as a covariate. Lipid oxidation of blood plasma and LL muscle was analyzed using a completely randomized design with repeated-measures based on values at 1, 33, 66 and 102 days of plasma sampling and LL muscle at 1, 7 and 14 days of aging.

3. Results and discussion

3.1. Growth and carcass characteristics

Palm oil contains a high percentage of saturated fatty acids, mainly palmitic acid (16:0) plus myristic acid (14:0) (Manso, Bodas, Castro, Jimeno, & Mantecon, 2009) and canola oil contains a high percentage of polyunsaturated fatty acids mainly linolenic (18:3n − 3) and linoleic (18:2n − 6) fatty acids (Kwan, Snook, Wardlaw, & Hwang, 1991). The inclusion of either palm or canola oil at 3% in the diet did not affect growth rate or carcass weight ($P > 0.05$; Table 2). The similarity in dry matter intake of diets with the same ME and CP reflects the fact the kids grew at similar rates and thus had similar carcass weights at the end of the feeding period. Castro, Manso, Mantecon, Guirao, and Jimeno (2005) reported that palm oil as calcium soap had no significant effect on carcass characteristics of lambs. In a study that evaluated the effect of a diet supplemented with sunflower oil on carcass composition and meat quality in kids, Marinova et al. (2001) also reported no effect on growth rate and carcass characteristics. These together suggest that an oil supplement of any type or form (saturated or unsaturated) as