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Fatty acid composition of minced meat, longissimus muscle and omental fat from Small East African goats finished on different levels of concentrate supplementation

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ABSTRACT

Effects of supplementing Small East African (SEA) goats with concentrate diets on fatty acids composition of minced meat, M. *longissimus dorsi* (LD) and omental fat were assessed using 23 animals (14.5 months old and 20.1 kg body weight). Goats were subjected to four levels of concentrate supplementation: *ad libitum* concentrate allowance (T100), 66% (T66), 33% (T33) and 0% (T0) of *ad libitum* concentrate allowance. All goats were slaughtered after 90 days of experimental period. Minced meat from concentrate-supplemented goats had higher ($P<0.05$) proportions of unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA) and desirable fatty acid (DFA) than that of non-supplemented ones (T0). Minced meat from T00 and T66 goats had similar proportions of polyunsaturated fatty acids (PUFA) and n-6 PUFA that were higher ($P<0.05$) than that of other dietary groups. There was limited variation in fatty acids composition of LD attributable to concentrate supplementation. Trans-vaccenic and linoleic acids were in higher ($P<0.05$) proportion in omental fat from concentrate-supplemented goats whereas margaric and arachidonic acids were in higher ($P<0.05$) proportion in omental fat from non-supplemented goats. Overall, LD was associated with PUFA, omental fat with saturated fatty acids (SFA), minced meat with MUFA. It is concluded that finishing SEA goats on concentrate diets will increase the proportion of DFA in meat from them. In addition, the proportion of PUFA in meat from such goats will peak at concentrate supplementation equivalent to 66% of their *ad libitum* intake. Consumers should avoid high intake of internal fat due to their richness in SFA.

1. Introduction

Goats are known to produce relatively lean meat, which is suitable for health conscious consumers. However, despite the importance of goats as source of lean meat, nutritive value of goat meat has received little research attention. There is limited information on fatty acids profile of meat and adipose tissue from goats (Dhanda, Taylor, Murray, & McCosker, 1999; Banskalieva, Sahlu, & Goetsch, 2000; Werdi Pratiwi, Murray, Taylor, & Zhang, 2006). In Tanzania, for instance, there is no published information on the fatty acid composition of goat meat, although goat is next to beef as a source of animal protein. Population of goats in Tanzania is estimated to be 13.5 million (MAFS, 2002). Chemical and physical properties of fatty acids affect nutritive value, palatability, appearance and shelf life of meat (Sheridan, Hoffman, & Ferreira, 2003; Webb, Casey, & Simela, 2005). It is well documented that long chain saturated fatty acids elevate levels of plasma cholesterol, which is a risk factor for atherosclerosis (Rao, Kowale, & Verma, 2003; Velasco et al., 2001). Unsaturated fats, on the other hand, have various health benefits including ability to reduce arteriosclerosis and thrombotic tendency of blood, the activity associated mainly with n-3 PUFA, especially C18:3 (Caneque et al., 2003).

Meat goats in Tanzania are maintained mostly on forages to minimize production cost. Pasture-based production systems, however, are characterized by low animal productivity due to seasonal variation in quality and quantity of feeds. This means that pasture alone does not always provide adequate nutrition to support fast growth. This entails supply of additional protein and energy, in a form of good hay or concentrate, to maintain acceptable growth performance (Lee, Kouakou, & Kannan, 2008). Information on the effects of dietary supplementation on body composition of meat goats is important as it may serve as a basis for changing carcass composition to suit consumers' interest (Sheridan et al., 2003). Reports show that diet affects the fatty acid profile of adipose tissue (Aurousseau et al., 2007; Dhanda et al., 1999). Diaz et al. (2002) showed that n-3:n-6 PUFA ratio is affected by the proportion of grass and concentrate in a diet. There is, however, paucity of information on the effects of feeding intervention on fatty acid composition of goat meat.

Fatty acid composition for different fat depots including subcutaneous, intra- and inter-muscular as well as visceral fat is well documented in cattle (Webb, De Smet, Van Nevel, Martens, & Demeyer, 1998; Talpur, Bhanger, & Khuhawar, 2007). Due to increasing importance of goat as a source of meat (Mahgoub et al., 2002), there is a need to profile fatty acid

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composition for various fat depots, the area which has suffered lack of adequate research attention (Banskalieva et al., 2000; Talpur, Bhanger, & Sherazi, 2008). Where reports on fatty acids composition of goat meat exist, they are mainly based on carcass fat. Limited reports on fatty acids composition of internal fat from goats do exist. In areas where internal fat forms part of fat consumed on a regular basis, as in developing countries, profiling fatty acid composition of internal fat becomes equally important. The objective of the present study was therefore to profile fatty acid composition of minced meat, M. *longissimus dorsi* and omental fat from local Small East African goats finished on different levels of concentrate supplementation.

2. Materials and methods

2.1. Animals and treatments

This experiment is explained in detail in Safari, Mushi, Mtenga, Kifaro, and Eik (2009). Briefly, 23 castrated SEA goats (14.5 ± 0.5 months old and 20.1 ± 1.2 kg body weight) were allotted into 6 weight blocks and assigned at random, within blocks, to one of four dietary treatments in a completely randomised block design. Dietary treatments were: T0, whereby no concentrate supplementation was offered; T33 and T66 whereby the amount of concentrate on offer was equivalent to 33% and 66%, respectively, of *ad libitum* concentrate intake. The fourth treatment, T100, involved feeding concentrate *ad libitum* allowing 10% refusal rate. Following the death of one animal caused by septicaemia before the end of the experiment, the number of animals in T33 and other treatments were 5 and 6, respectively.

2.2. Feeding management

Animals were given a three-week adaptation period during which they were treated with Ivermectin against internal and external parasites. Goats were individually stall-fed, having free access to water. Grass hay was offered *ad libitum* at 20% refusal rate. Hay and concentrate were fed twice daily and water was available freely. During the experimental period, which lasted for 90 days, feed allocations and refusals were recorded daily for each goat. Animals were weighed weekly before morning feeding.

2.3. Sampling of minced meat, LD muscle and omental fat for fatty acid analyses

At the end of the experimental period, goats were fasted for 16 h before slaughter. Each carcass was dissected longitudinally into two equal halves through the median plane using a band saw, 45 min post-mortem. The carcasses were chilled at 0 °C for 24 h before sampling. Each left-half carcass was dissected into muscle, fat and bone for estimation of carcass composition. M. *longissimus dorsi* (LD) was split into blocks measuring approx. 7 cm long. One block, at the posterior end of LD, was used for fatty acid analyses. The remaining carcass muscles and fat tissues were thoroughly mixed together, minced (5 mm sieve) and three sub-samples were taken for fatty acid analyses. Approximately 10 g of omental fat also was sampled for fatty acid analyses. All samples were packed in PVC bags and frozen at −25 °C until analyses were done.

2.4. Fatty acid analyses

Analysis of fatty acids in the samples was carried out at the Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, Norway. Fatty acid methyl esters (FAME) synthesis was done following the direct method of O'Fallon, Busboom, Nelson, and Gaskins (2007). After FAME synthesis, 3 mL of hexane were added to each reaction tube, and the tubes were vortex-mixed for 5 min on a multitube vortex. The tubes were centrifuged for 5 min at 3000 rpm in a tabletop centrifuge (Wifug Ltd, England). From each tube, the hexane layer containing the FAME, was transferred into a gas chromatography (GC) vial. Each vial was capped and placed at −20 °C before fatty acid separation in a GC.

Fatty acids methyl esters were separated in a Thermo Finnigan Focus GC equipped with automatic injector, restek capillary column (Rt-2560; 0.25 mm internal diameter, 100 m long; stationary phase: 90% biscyanopropyl, 10% cyanopropylphenyl polysiloxane) and flame ionization detector. Samples were injected in a split mode (1:40). The carrier gas was Helium, and the column head pressure was 280 kPa. Oven temperature programming was: 70 °C for 2 min, 70 to 150 °C for 4 min, 150 °C for 34 min, 150 to 230 °C for 57 min, and a final temperature at 230 °C for 10 min. The injection temperature was 230 °C and detection temperature was 255 °C. The identification of individual FAME in the samples was achieved by matching the retention time of the unknown FAME with that of a known FAME from standard mixtures (FAME mix, 37 components, Supelco™). Fatty acid composition in the samples was calculated as peak area percentages for each fatty acid, including unidentified fatty acids. Software, integration calibration program (Chromeleon, V6.7) connected to the chromatograph, which converts relative peak areas into weight percentages, was used for calculations.

2.5. Physical and chemical compositions of dietary feeds

The grass hay consisted of *Bracharia* spp. (70%) and *Bothrocloa* spp. (30%). Concentrate supplement consisted of 28% sunflower seed cake, 70% maize bran, 1.3% lime, 0.2% salt, and 0.5% mineral mix, with crude protein of 16.2% and estimated metabolisable energy of 13.4 MJ/kg DM. Proximate compositions of both the grass hay and concentrate diet are reported elsewhere (Safari et al., 2009). Fatty acid profile of the concentrate diet is shown in Table 1.

2.6. Statistical analysis

Experimental data were analysed using the General Linear Model Procedure of SAS (2001). Dietary treatments were considered as fixed effects and residual as random effect. Each individual animal served as an experimental unit for all the parameters assessed. Due to small variation in age of animals within treatments, all traits were corrected by animal age as a covariate. In all analyses, when Least Square Means were significantly different by ANOVA at $P<0.05$, were separated by PDIFF option of SAS.

In order to determine the distribution of fatty acids in different fat depots (omental, LD muscle and minced meat), principal component analysis (PCA) was carried out on fatty acid compositions across the

Table 1
Fatty acid profile of the concentrate diet.

Fatty acid	Structure	Content (mg/100 mg)
Palmitic	C16:0	12.30
Palmitoleic	C16:1n7	0.10
Stearic	C18:0	2.90
Oleic	C18:1n9c	33.10
Linoleic	C18:2n6c	46.80
Eicosanoic	C20:0	0.50
Linolenic	C18:3n3	0.40
Behenic	C22:0	0.32
Erucic	C22:1n9	0.01
Lignoceric	C24:0	0.30
Docosapentaenoic	C22:5n3	0.03
Docosahexaenoic	C22:6n3	0.01
Total saturated	SFA	16.90
Total unsaturated	UFA	82.30
Total monounsaturated	MUFA	34.80
Total polyunsaturated	PUFA	47.47
Total n-6	n-6 PUFA	46.88
Total n-3	n-3 PUFA	0.47