Peer-reviewed paper: 8th International Conference on Goats

Influence of various levels of metabolisable energy on chemical composition of whole carcass and non-carcass portion of goats and sheep

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Abstract

Two comparative slaughter studies using 24 male goats and 40 Omani male sheep lambs were carried out to determine the effects of various levels of metabolisable energy (ME) on chemical composition of carcass and non-carcass portions. Eighteen goats and 30 lambs were divided randomly into four groups. Group 1 (6 goats and 10 lambs) was slaughtered at the onset of the trial, while the remaining groups were fed one of three diets containing 8.67, 9.95 or 11.22 MJ ME/kg DM from weaning until slaughter. The feeding trial continued for 141 d for goats and 123 d for sheep. Dietary energy density had a significant effect on the slaughter weight in both sheep and goats. Carcass water and fat percentages were affected significantly by the dietary energy density. Non-carcass water, protein and fat were also affected significantly by the dietary energy density. With increasing age and body weight (comparing the initial slaughter group and those slaughtered at the end of the trial), content of water, crude protein and ash decreased whereas that of fat increased in carcass portions of both goat and sheep. Goat carcasses contained more water than sheep. On a dry matter basis, goat carcasses contained significantly lower fat and ash but higher protein levels than sheep. This emphasises the ability of goats to produce leaner carcasses than sheep, which is a preferable meat characteristic to consumers. Responses to dietary energy manipulation were quite different between goats and sheep in terms of carcass and non-carcass composition as interactions between species and diet were significant.

Keywords: Energy levels, chemical composition, carcass
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Introduction

Goat and sheep are significant meat producing animals with goats being the more important in the less developed parts of the world. There are about 768 million goats and 1,028 billion sheep in the world. Oman has 998,000 goats and 354,000 sheep (FAO, 2004). In the tropics, especially for animals raised under traditional systems, energy intake fluctuates according to the season and the ability of owners to provide supplementary feeding. This should have an impact on meat production as animals may use more energy searching for grazing over long distance than the energy they gain from this poor quality feed.

The objectives of this study were to investigate the effects of various levels of metabolisable energy (ME) on chemical composition of carcass and non-carcass portions of Omani goats and sheep.

Materials and Methods

Two separate experiments using 40 Omani male sheep lambs and 24 male goat kids were carried out at the Sultan Qaboos University Agriculture Experiment Station. Animals were randomly assigned after weaning to one of the four treatment groups (10 sheep and 6 goats per treatment). Animals in Treatment Group 1 were slaughtered at the onset of the experiment for initial carcass composition. Animals in the remaining three groups were assigned randomly to one of three dietary treatments containing 8.67, 9.95 or 11.22 MJ ME/kg dry matter (DM). The ingredients and chemical analysis of the diets, which were offered as a total mixed diet, are presented in Table 1. Lams and kids stayed with their dams and fed creep feed *ad libitum* from birth to weaning at an average age of 80 days. From weaning to slaughter the lambs were individually housed in pens (1x2 m) and fed the respective experimental diets until slaughter at 140 days for goats and at 123 days for sheep. Animals were weighed weekly. A digestibility trial was carried out using four lambs of each treatment for a 2-week adjustment and 1-week collection period to determine digestible and metabolisable energy. Feed, faecal and urine samples were collected daily to determine their energy content. At slaughter, blood was collected in plastic trays and transferred into plastic bags. Non-carcass components included blood, head, feet, skin, liver, spleen, heart, lungs and trachea, empty digestive tract, pancreas, non-carcass fat depots (kidney, pelvic and scrotal) and testicles. The total weight of non-carcass organs and tissues was determined and the samples were stored frozen in plastic bags at –20 °C. Digestive tract content was calculated as the difference between full and empty digestive tract. The carcass was wrapped in a polyethylene bag and stored at –20 °C. Carcasses were split along the midline with a band-saw. Both the frozen left half carcass and non-carcass a portion were ground separately in a whole carcass grinder. The product was further ground in a meat grinder fitted with a finer screen and well mixed before samples were collected for chemical analyses. The Proximate analysis was carried out on the minced samples for DM, crude protein (CP), ether extract (EE) and ash according to the methods of the AOAC (2000). Experimental data were analysed using General Linear Model procedures of analysis of variance (SAS, 1991).

Results and Discussion

The three formulated experimental diets were iso-nitrogenous. By design there was an inverse relationship between dietary energy density and acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations (Table 1). This is a direct result of higher forage (Rhodes grass hay) and lower concentrate (barley grain) percentages in the lower energy diets. The ration composition was comparable to the standard diets for sheep and goats and met the nutritional requirements for growing goats and sheep (NRC, 1981; 1985).

Table 1 Ration formulation and chemical composition of diets containing three levels of metabolisable energy (ME) fed to Omani goats and sheep

	Dietary energy concentration		
Ingredient, g/kg	Low	Medium	High
Rhodes grass hay	600	400	200
Barley grain	190	400	400
Maize grain	-	17	226
Soyabean meal (44% CP)	170	173	134
Maize oil	12	10	8
Limestone	8	10	12
Vitamin/mineral premix	10	10	10
Sodium bicarbonate	10	10	10
Chemical composition, g/kg DM			
Crude protein	162	160	160
Neutral detergent fibre	443	341	237
Acid detergent fibre	258	186	124
Ash	79	69	62
Calcium	8.9	8.9	8.8
Phosphorus	1.9	2.3	2.8

The digestibility for the DM, as expected, was inversely correlated with the fibre content of the diet. A similar pattern was observed with digestibility of DE and ME (54.19, 54.91 and 59.79% for low-, medium-, and high-ME diets, respectively). The ratio between DE and ME for low-, medium- and high-energy diets was 0.82, 0.82 and 0.81 respectively. This is similar to that suggested by the NRC (1985) for diets which do not contain a high grain component.

At slaughter goats were older but with a lower body weight than sheep, although they stayed longer on trial (141 *vs*. 123 days). According to Lu & Pochoiba (1981), growth rate of Omani goats was about half that of Alpine and Nubian goats. We speculated that the growing goats might have been less adaptive than sheep to confinement because they grew at a slower rate than sheep (Mahgoub & Lodge, 1998). There was a trend of increasing body weight with increasing ME levels. However, this was more pronounced in sheep than in goats. By the end of each study the high ME level goats were 13% heavier and the high ME sheep 26% heavier that corresponding animals on the lower ME diets (Table 3). This could imply that Omani sheep adapted abetter to improved management conditions, which may be an important consideration for management decisions for small ruminant farmers in the tropics.

Table 2 Dry matter and energy digestibility of iso-nitrogenous diets containing low-, medium- and high energy concentrations

	Dietary energy concentration			Pooled
	Low	Medium	High	s.e.
Digestible dry matter (%)	66.9^{b}	68.7^{ab}	73.9^{a}	0.59
Gross energy (MJ/kg DM)	18.2^{b}	18.7^{a}	18.9^{a}	0.13
Digestible energy				
Digestion coefficient (%)	66.8^{b}	67.2^{ab}	73.3^{a}	0.43
Diet concentration (MJ/kg)	12.2^{c}	12.6^{b}	13.9^{a}	0.08

^{a,b,c}Means in the same row without a common superscript differ significantly at P < 0.05

With increasing age and body weight (comparing the initial slaughter group and those slaughtered later in the trial), water, CP and ash concentrations decreased whereas that of fat increased in carcasses of both goats and sheep. Goat carcasses contained higher water levels than sheep (Table 3). On a DM basis, goat carcasses contained a lower fat and ash, but higher protein content than sheep. This emphasises the ability of goats to produce leaner carcasses than sheep, which is a preferable meat characteristic to consumers.

There was a trend of increasing fat content and a decreasing protein and ash content with increasing levels of ME in carcasses of goats and sheep. These results are in line with native Sabi sheep in Zimbabwe (Kusina *et al.*, 1991). Compared with Sabi sheep, the Omani sheep and the goats studied, were slaughtered at approximately two-thirds of their mature weight. This implies that the most variable and late-maturing carcass component, fat, is still at the early stages of maturity, which may explain the lack of significance differences in carcass composition.

Table 3 Mean chemical composition of carcass and non-carcass portions in Omani goat and sheep fed diets containing various levels of metabolisable energy (ME)

	Goats					Sheep					Effect; P <		
Item	Ref.	Low§	Med.§	High§	s.e.m.	Ref.	Low§	Med.§	High§	s.e.m.	Spp	Diet	SppxDiet
Trial period (d)		141	141	141			123	123	123				
Age (d)	152	269	269	268	3	74	191	195	194	3	***	***	NS
Slaught. wt (kg)	15.4	22.5	23.8	25.4	2.40	15.2	27.4	30.2	34.4	1.85	*	***	NS
Carcass (g/kg DM)													
Water	613	598	573	568	17	548	510	505	489	13	***	**	NS
Crude protein	452	472	398	401	21	347	346	310	299	17	***	NS	*
Fat	406	427	457	531	25	520	571	587	604	21	***	*	NS
Ash	91	66	58	33	12	81	85	74	76	9	*	NS	*
Non-carcass (g/kg DM)													
Water	598	616	598	580	11	639	550	540	525	9	***	***	***
Crude protein	416	452	425	402	17	485	358	347	387	14	*	***	***
Fat	416	384	453	455	19	396	452	476	505	15	*	**	***
Ash	95	87	95	91	12	79	62	77	94	9	***	NS	NS

Spp - species; NS – not significant; *P < 0.05; **P < 0.01; ***P < 0.001
§ ME levels

In the non-carcass portion goats and sheep fed the high-energy diet had higher fat levels than those fed the low-energy diet. Non-carcass fat matures earlier (Butterfield, 1988) and, therefore, effects of energy density of the diets are more likely to be observed than in the later maturing carcass fat. For both carcass and non-carcass portions, CP decreased whereas fat increased. This is in line with findings in sheep (Butterfield, 1988), since fat is a late maturing body tissue. Animals fed the low-energy diet had higher protein and lower fat levels in the carcass portion that those fed the medium- and high-energy diets. This is similar to findings reported in cattle (Ferrell *et al*., 1978) and in sheep (Ferrel *et al*., 1979). Interestingly, there was a trend of increasing ash concentrations with increasing energy levels in the non-carcass portion of both sheep and goats. This is the opposite of the decreasing ash content observed for the carcass (Table 3). This might be attributed to the increased growth rates of the wool and hair.

Conclusions

Under the identical feeding and management conditions outlined in this study, sheep seem to be a faster growing species than goats. This study indicated that goat carcass and non-carcass portions contain lower fat and higher protein than those of sheep. Increasing levels of dietary ME increased fat and reduced the protein content of carcass and non-carcass portions in both sheep and goats.

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