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Effect of tail docking in Awassi lambs on metabolizable energy requirements and chemical composition of carcasses

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Abstract

The effect of tail docking on metabolizable energy requirements and carcass characteristics was studied using 80 weaned entire Awassi male lambs. Docking was performed within 3 days of birth and lambs were weaned at 90 days old. Docked and undocked lambs were randomly allocated to four groups, individually penned and offered different amounts of a pelleted concentrate diet. The pelleted diet was estimated to contain 11·8 MJ of metabolizable energy (ME) and 182 g of crude protein (CP) per kg dry matter (DM). Lambs on the high levels of intake were slaughtered at a target weight of approximately 45 kg. Other lambs were maintained on the diet for 149 days before being slaughtered. The right sides of all carcasses were cut into standardized commercial cuts then dissected into muscle, fat and bone. The soft tissue was pooled and analysed for DM, CP, ash and fat. Prediction of live-weight gain (LWG) and empty body gain for a given ME intake (MEI) was made using the growth and MEI data. MEI was expressed as MJ per kg metabolic body weight ($M^{0{\cdot}75}$) per day.

Tail docking had no effect ($P > 0{\cdot}05$) on lamb growth from birth to weaning. During the post-weaning growth period, LWG and empty body gain were significantly higher ($P < 0{\cdot}05$) for undocked lambs than docked lambs, at feeding levels between 0·31 and 0·52 MJ/kg $M^{0{\cdot}75}$ per day and similar ($P > 0{\cdot}05$) at high levels of intakes (between 0·74 and 1·1 MJ/ kg $M^{0{\cdot}75}$ per day). Hot and cold carcass weights were similar ($P > 0{\cdot}05$) for the two groups. Differences in empty body weight and fleece-free empty body weight were significant ($P < 0{\cdot}05$) only for the 0·443 to 0·522 MJ/kg $M^{0{\cdot}75}$ per day level of ME intake. Predicted ME requirements were higher for docked lambs for an estimated LWG between 0 and 100 g/day and lower for higher LWG (125 to 225 g/day). Docking had no effect ($P > 0{\cdot}05$) on food conversion efficiency (FCE).

Carcasses from docked lambs had significantly lower ($P < 0{\cdot}001$) internal plus tail fat. Pooled soft tissue excluding tail fat, for the undocked lambs contained significantly more ($P < 0{\cdot}01$) protein, less ($P < 0{\cdot}001$) fat, higher ($P < 0{\cdot}01$) moisture and similar ($P > 0{\cdot}05$) ash content.

Keywords: *Awassi, carcass composition, docking, energy requirements, lambs.*

Introduction

Awassi is the most popular fat-tailed sheep breed in Middle Eastern countries. These sheep are kept mainly for meat and milk production while wool is often considered as a by-product particularly after the rise in recent years in the labour cost associated with shearing. Tail docking in Awassi sheep is not a common practice in sheep farming in Middle Eastern countries. However, several tail docking experiments have been carried out in an attempt to improve the growth, food conversion efficiency and carcass characteristics of lambs (Epstein, 1961; Farhan *et al.*, 1969; O'Donovan *et al.*, 1973; Alkass *et al.*, 1985; Shelton *et al.*, 1991). The fat tail plays an important rôle in adaptation in sheep raised under the harsh feeding conditions of arid and semi-arid regions, where the availability of foodstuffs, and especially of good quality roughage is seasonal. As an important part of the fat pool it was anticipated that tail docking would result in lower metabolizable energy (ME) requirements due to lower fat deposition. The tail has also been reported to have a negative impact on reproductive performance and lamb production from fat-tailed Karakul sheep (Shelton, 1990). Changes in consumer preferences favouring leaner meat and the growing awareness of the dangers of high-fat diets, as well as the availability of alternative cheaper and healthier fat sources, has resulted in a reduced demand for sheep with tail fat in Middle Eastern countries. This study was designed to investigate the effect of tail docking in Awassi lambs on (i) the ME requirements for maintenance and growth, and (ii) the chemical composition of carcasses from tail-docked lambs.

Material and methods

Experiment 1: growth study

Lambs and their management. Sixty-four weaned Awassi ram lambs (32 undocked and 32 docked), born between October and December 1992 were used in a 2 × 4 factorial experiment with tail docking as the main treatment and four levels of metabolizable energy intake (MEI) as sub-treatments. The lambs were randomly selected from the sheep flock maintained on the Agricultural Research Centre farm of the Jordan University of Science and Technology, northern Jordan (32º36′N, 35º57′E). Docking was performed within 3 days of birth by applying a tight rubber ring between the first and the second vertebrae down the tail. The tail fell off within 2 to 3 weeks without further interference. Lambs were kept with their mothers for about 90 days before being weaned. After weaning the lambs were individually penned and offered a pelleted concentrate mixture, which had been used in the metabolizable energy study (experiment 2) to determine its capacity to provide digestible nutrients. The pelleted diet was offered at four levels to provide ME intakes ranging from 0·31 to 1·15 MJ/kg $M^{0.75}$ per day. Live weights were recorded at birth, weaning and twice weekly during the post-weaning feeding period. Food intake during the post-weaning period was measured as the difference between food offered and refused. The efficiency of food conversion into live weight (FCE) was calculated as kg dry matter (DM) intake per kg live-weight gain. However, FCE was calculated only for the groups with high levels of energy intake (MEI ≥ 0·743 MJ/kg $M^{0.75}$ per day) that had a constantly high LWG.

Sixteen other weaned lambs (eight undocked and eight docked), of similar body weight were slaughtered at the beginning of the growth experiment to predict initial empty body weight for lambs in the growth experiment, and to establish a relationship between this and final empty body weight.

Diets and feeding. During the suckling period, lambs had access to a creep diet formulated to provide high levels of protein and fermentable carbohydrates. The diet consisted of (g/kg fresh basis) 480 barley, 100 wheat bran, 300 soya-bean meal (US origin, 480 g/kg crude protein (CP)), 100 yellow maize, 15 dibasic calcium phosphate, 4 NaCl and 1 minerals and vitamins mixture. The minerals and vitamins mixture consisted of (composition per kg), retinol 135 mg, cholecalciferol 27·5 mg, alpha-tocopherol 3·2 g, Mn 10·9 g, I 1·1 g, Zn 22·7 g, Fe 22·7 g, Cu 2·7 g, Co 0·635 g, Mg 100 g, Se 0·1 g plus antioxidant. The grains were reduced in a hammer mill to pass through a 6·25-mm screen.

The pelleted diet given post weaning consisted of (g/kg fresh basis) 500 barley, 200 wheat bran, 200 soya-bean meal (US origin, 480 g/kg CP), 80 yellow maize, 15 dibasic calcium phosphate, 4 NaCl and 1 minerals and vitamins mixture (same as in the creep diet). The pelleted diet was estimated to provide 11·8 MJ ME per kg DM and 182 g of CP per kg DM. Coarsely milled wheat straw (0·5 to 1 cm in length) was offered to all lambs at a rate of approximately 90 g DM per lamb per day, in order to minimize the risk of acidosis caused by the high levels of concentrate feeding.

Slaughter and carcass composition measurements. Lambs maintained on low levels of MEI (0·35 and 0·50 MJ/kg $M^{0.75}$ per day) were slaughtered at the end of a 149 day feeding period. Other lambs were slaughtered after reaching a live weight of approximately 45 kg. Before slaughter, lambs were deprived of food overnight and allowed access to fresh water. Lambs were weighed fasted 1 h before slaughter to record slaughter weight (SW) then shorn and weighed again to calculate fleece-free empty body weight (FFEBW). The head was removed between the occipital bone (skull) and the first cervical vertebrae. The feet were removed between the carpus and metacarpus (knee joint) and the tarsus and metatarsus (hock joint). Air inflation was applied to aid in the removal of the skin. The digestive tract was removed, weighed full and then empty to calculate empty body weight (EBW) and FFEBW. Omental fat (OF), pelvic and kidney fat (PKF) and canal fat (CF) was separated from the carcass and weighed. After skinning and evisceration of all internal digestive, respiratory, circulatory, excretory and reproductive organs, carcasses were weighed hot to record hot carcass weight (HCW), then chilled for 24 h at 4ºC to record chilled carcass weight (CCW). After removing the tail from carcasses of undocked lambs chilled carcasses were split into sides by dividing the spinal column down its length. The left side was discarded and the right side was cut into standardized wholesale cuts (Aus-Meat, 1990). The cuts were weighed separately and dissected into lean, fat and bone. The three components were weighed and the soft tissue (lean and fat) for the whole side was pooled and minced repeatedly using a heavy duty mincer, starting with 13-mm then 6-mm plate size, until a uniform product was obtained. The tail was not included with the soft tissue but analysed separately for moisture and fat content.

Experiment 2 : metabolizable energy study

Lambs and their management. Nine Awassi lambs not used in experiment 1, with a mean live weight of 48·6 kg (s.e. 0·62) and 9 months old were randomly divided into three groups, and allocated to three levels of MEI (0·421, 0·550, and 0·777 MJ/kg $M^{0.75}$ per day). The choice of three levels of intake was to represent MEI treatments in the growth experiment and to measure the possible effect of intake on the digestibility of energy. Lambs were housed individually and allowed 14 days to adapt to the diet. They had free access to fresh water. Lambs were then placed in metabolism cages for a 5-day adaptation period followed by a 7-day collection period, during which food offered and food refused were recorded and separate daily collections of total faeces and urine were made.

Chemical analyses

Samples of food offered, food refused and faeces collected were dried at 50ºC until a constant weight was achieved and the dry matter calculated. Prior to chemical analyses samples were ground to pass through a 1-mm screen. Samples were analysed for DM and total nitrogen content by standard official methods (Association of Official Analytical Chemists (AOAC), 1984). Gross energy (GE) content of the diet and faeces were measured by bomb calorimeter (Parr Instrument Co., Moline, Illinois, USA). MEI was calculated as 0·81 × digestible energy (DE) intake (Ministry of Agriculture, Fisheries and Food, 1987), and DE was estimated as the difference between GE of food intake and GE output in the faeces.

Duplicate samples were taken from the minced soft tissue and dried by a forced draft oven at 100ºC for 12 h to determine the moisture content. Other samples were freeze-dried for further chemical analysis. Moisture, crude protein (N × 6·25), ether extract and total ash contents were determined by standard methods (AOAC, 1984).

Table 1 *Chemical composition of the creep diet, the pelleted concentrate mixture and wheat straw (g/kg dry matter (DM))*

	Creep diet	Concentrate	Straw
Crude protein	234	182	46
Acid-detergent fibre	80	81	442
Neutral-detergent fibre	441	448	728
Organic matter	931	928	916
Estimated ME† (MJ/kg DM)	12·0	11·8	6·6

† From the metabolizable energy study.

Statistical analysis

The observed values of MEI were grouped into four levels, though there was some variation of the MEI values within levels. This grouping was useful in providing a convenient summary (e.g. as means and their standard errors) of the data into levels for the docked (D) and undocked (U) lambs. The magnitude and variance of most parameters measured changed sharply with each level of MEI. Therefore, statistical significance could not be accurately assessed by the routine application of analysis of variance due to variance heterogeneity and unequal category replication. Rather, a set of eight contrasts was used with their standard errors calculated from within the category variances. The first four contrasts were the within-level differences (U-D) followed by an overall comparison of the differences, and the remaining three are polynomials, orthogonal with respect to the mean category values of MEI (i.e. linear (L), quadratic (Q) and cubic (C) contrasts). Approximate *t* tests (Stuart and Ord, 1991) were then used to test for statistical significance for each of the contrasts. Changing levels of significance over the first four contrasts imply an interaction between U-D and MEI levels, i.e. a different response to increasing MEI for U and D sheep. Data for daily ME intakes and cold carcass weight were transformed to $\log_{10}$ to minimize correlations between the mean and variance and then used to establish the relationship between ME intakes and cold carcass weight and each of the different fat components (OF, PKF, CF and total fat).

Results

Chemical composition of the diets, food intake, animal growth and food conversion efficiency

Chemical composition of the creep diet, the concentrate mixture and the straw are presented in Table 1. Live-weight gain of lambs from birth to

Table 2 *Effect of tail docking and level of metabolizable energy intake (MEI) on live-weight gain (LWG), empty body gain (EBG), slaughter weight (SW), empty body weight (EBW), fleece-free empty body weight (FFEBW), food conversion efficiency (FCE) and dressing proportion*

Parameters	Undocked				Docked			
	MEI† (MJ/kg M$^{0·75}$ per day) ± s.e.				MEI (MJ/kg M$^{0·75}$ per day) ± s.e.			
	0·329±0·005	0·502±0·006	0·774±0·011	0·972±0·011	0·361±0·003	0·492±0·009	0·760±0·010	0·996±0·030
MEI range	0·309–0·345	0·477–0·522	0·745–0·823	0·911–1·027	0·347–0·367	0·443–0·522	0·743–0·797	0·878–1·149
No. of lambs	6	7	6	12	7	7	5	11
Initial weight (kg)	26·8±2·3	28·9±1·7	28·9±1·4	28·1±1·3	24·4±1·3	25·7±2·0	26·1±2·7	27·5±1·8
Final weight (kg)	28·9±2·8	38·6^{a}±1·7	44·9±1·4	48·9±1·4	24·6±1·0	31·7^{b}±2·3	46·8±1·5	48·1±1·2
Days on food	149	149	85	79	149	149	101	78
LWG (g/day)	14^{a}±4·2	64^{A}±3·4	189±13·5	265±12·0	1^{b}±3·4	41^{B}±3·1	206±12·3	263±9·6
SW (kg)	28·7±2·8	37·5^{a}±1·5	43±1·6	46±1·1	24·6±1·0	31·1^{b}±2·2	45·3±1·4	45·3±1·0
EBW (kg)	25·3±2·5	32·9^{a}±1·2	38·7±1·6	42·7±1·1	19·9±1·3	27·4^{b}±1·8	40·7±1·6	40·9±1·0
FFEBW (kg)	24·8±2·4	32·2^{a}±1·3	37·4±1·5	41·4±1·0	19·3±1·3	26·5^{b}±1·8	39·3±1·6	38·8±1·3
EBG (g/day)	20^{A}±4·7	59^{A}±2·6	173±16·3	243±8·6	-7^{B}±3·1	35^{B}±2·7	181±14·1	219±11·4
FCE†	NA	NA	5·2±0·31	5·0±0·78	NA	NA	4·6±0·61	4·6±0·20
Dressing proportion (g/kg)								
Hot	44·8±0·74	49·3±0·87	50·9±0·61	52·6±0·78	45·0±1·70	52·2±0·66	51·6±0·58	51·9±1·10
Cold	43·7±0·83	48·3±0·85	50·1±0·57	52·1±0·80	43·6±1·80	51·1±0·66	50·9±0·65	51·2±1·20

Means within a row with a different superscript are significantly different (differences are within MEI levels between undocked and docked); ^{a,b} $P < 0·05$, ^{A,B} $P < 0·001$.

† FCE expressed as kg dry-matter intake per kg LWG; NA, not applicable.

weaning (approx. 70 days old) was similar (257 (s.e. 9) and 258 (s.e. 9) g/day respectively for the undocked and docked lambs). Removing the tail did not significantly affect ($P > 0·05$) food intake during the post-weaning growth period. However, undocked lambs grew significantly faster ($P < 0·05$) at lower levels of MEI (0·309 to 0·522 MJ/kg M$^{0·75}$ per day) (Table 2). No significant differences in growth rate were observed at higher levels of MEI (0·75 to 1·0 MJ/kg M$^{0·75}$ per day). Similarly, empty body gain (EBG) was significantly higher ($P < 0·05$) for the undocked lambs at the same low levels of MEI with no significant differences at higher levels of intake. Docked lambs at the lowest level of MEI (0·309 to 0·367 MJ/kg M$^{0·75}$ per day) lost 7 g/day while the undocked lambs on the same level of MEI were in a positive energy balance and gained 20 g/day. Final weight was significantly higher ($P < 0·001$) for the undocked lambs that had a MEI of 0·443 to 0·522 MJ/kg M$^{0·75}$ per day than for their docked equivalents. FCE was similar ($P > 0·05$) across all treatments.

Energy requirements for maintenance and growth

Predicted ME requirements for a given LWG and EBG are presented in Table 3. For both growth parameters, ME requirements tended to be higher for docked than for undocked lambs gaining from 0 to 100 g/day and lower when they were gaining between 100 and 200 g/day. The ME requirement for maintenance was 0·28 for the undocked and 0·35 MJ/

Table 3 *Predicted metabolizable energy requirements (MJ/kg M$^{0·75}$ per day) for live-weight gain (LWG) and empty body gain (EBG)*

	LWG (g/day)												
	0	25	50	75	100	125	150	175	200	225	250	275	300
Undocked	0·280	0·368	0·455	0·527	0·581	0·636	0·690	0·745	0·804	0·868	0·933	0·998	1·063
Docked	0·356	0·440	0·508	0·548	0·589	0·629	0·670	0·710	0·751	0·840	0·944	1·048	1·152
	EBG (g/day)												
	0	25	50	75	100	125	150	175	200	225	250	275	300
Undocked	0·240	0·352	0·463	0·541	0·601	0·660	0·720	0·781	0·851	0·922	0·992	1·062	1·133
Docked	0·383	0·462	0·520	0·566	0·612	0·657	0·703	0·749	0·878	1·033	1·188	1·344	1·499

Table 4 *Predicted live-weight gain (LWG) and empty body gain (EBG) for a given metabolizable energy intake (MEI)*

	MEI (MJ/kg $M^{0{\cdot}75}$ per day)								
	0·250	0·375	0·500	0·625	0·750	0·875	1·00	1·125	1·250
LWG (g/day)									
Undocked	–9	27	63	120	178	228	276	324	372
Docked	–32	6	45	122	200	233	263	294	324
EBG (g/day)									
Undocked	2	30	58	110	163	209	253	297	342
Docked	–43	–3	39	107	176	200	220	240	260

kg $M^{0{\cdot}75}$ per day for the docked lambs and 0·240 and 0·383 MJ/kg $M^{0{\cdot}75}$ per day when calculated on LWG and EBG respectively.

Predicted LWG for a given MEI is presented in Table 4. Predicted LWG tended to be lower for docked lambs at MEI levels ≤ 0·5 and ≥ 1·0 MJ/kg $M^{0{\cdot}75}$ per day and higher at intakes between 0·625 and 1·0 MJ/kg $M^{0{\cdot}75}$ per day.

Omental fat, pelvic and kidney fat, canal fat and total fat
The amounts of omental fat, pelvic and kidney fat, canal fat and total fat (including the fat tail for the undocked lambs and that accumulating over the rump for the docked lambs) are presented in Table 5. Although no significant effect ($P > 0{\cdot}05$) of docking was observed at the different levels of MEI ranging from 0·309 to 1·149 MJ/kg $M^{0{\cdot}75}$ per day, over all levels, docking significantly increased ($P < 0{\cdot}05$) omental fat by 229 (s.e. = 96) g. Undocked lambs had significantly higher ($P < 0{\cdot}01$) PKF at MEI ranging from 0·309 to 0·522 MJ/kg $M^{0{\cdot}75}$ per day and significantly lower ($P < 0{\cdot}05$) at higher MEI (between 0·743 and 1·149 MJ/kg $M^{0{\cdot}75}$ per day). However, differences at MEI between 0·878 to 1·149 MJ/kg $M^{0{\cdot}75}$ per day were not significant ($P > 0{\cdot}05$). No canal fat was deposited at MEI between 0·309 and 0·522 MJ/kg $M^{0{\cdot}75}$ per day in lambs from either group. At MEI between 0·743 and 1·149 MJ/kg $M^{0{\cdot}75}$ per day canal fat in the docked lambs was about double ($P < 0{\cdot}001$) that for the undocked lambs. When the weight of tail fat was added to weights of OF + PKF + CF the undocked lambs had a significantly higher ($P < 0{\cdot}001$) fat content than the docked lambs. The difference in total fat weight between the undocked and docked lambs ranged from 343 to 3645 g for MEI ranging from 0·309 to 1·149 MJ/kg $M^{0{\cdot}75}$ per day. The regression coefficients of the relationships between $\log_{10}$ CCW and $\log_{10}$MEI and OM, PKF, CF, and TF are presented in Table 6. Docking resulted in a statistically weaker relationship between OF, PKF, CF, and TF and both

Table 5 *Effect of tail docking and level of metabolizable energy intake (MEI)† on omental fat (OF), pelvic and kidney fat (PKF), canal fat (CF) and total fat (TF, including the tail)*

	MEI (MJ/kg $M^{0{\cdot}75}$ per day)			
	0·309 to 0·367	0·443 to 0·522	0·743 to 0·823	0·878 to 1·149
OF (g)				
Undocked	127±48†	421±63	692±179	740±76
Docked	332±142	608±176	1051±207	906±94
PKF (g)				
Undocked	76±18	180±23	207±51	304±51
Docked	0	0	484±80	416±61
Significance	**	***	*	
CF (g)				
Undocked	0	0	44±6	76±7
Docked	0	0	116±14	148±5
Significance			**	***
TF (g)				
Undocked	675±209	2189±313	3600±311	5115±279
Docked	332±142	608±176	1651±284	1470±140
Significance		**	***	***

† Values are means with s.e.

Table 6 *The effect of cold carcass weight ($\log_{10}$kg CCW) and metabolizable energy intake ($\log_{10}$MEI) on the deposition of omental fat (OF), pelvic and kidney fat (PKF), canal fat (CF), and total fat (TF) in undocked and docked lambs*

	Log_{10} CCW					Log_{10} MEI				
	Intercept	(s.e.)	Slope	(s.e.)	R^2†	Intercept	(s.e.)	Slope	(s.e.)	R^2
Log_{10} OF										
Undocked	–10·370	(1·095)	3·013	(0·254)	82·9	2·931	(0·075)	1·808	(0·288)	57·7
Docked	–5·068	(1·589)	1·828	(0·373)	46·2	2·998	(0·099)	1·440	(0·371)	35·0
Log_{10} PKF										
Undocked	–5·315	(1·100)	1·755	(0·256)	61·9	2·444	(0·056)	1·119	(0·213)	48·7
Docked	–3·375	(4·269)	1·363	(0·973)	12·3	2·587	(0·058)	–0·377	(0·772)	1·7
Log_{10} CF										
Undocked	–10·336	(2·280)	2·762	(0·520)	63·8	1·889	(0·044)	2·392	(0·662)	44·9
Docked	–0·197	(2·036)	0·531	(0·464)	8·5	2·159	(0·024)	0·703	(0·311)	26·7
Log_{10} TF										
Undocked	–8·852	(0·616)	2·847	(0·143)	93·2	3·759	(0·044)	1·919	(0·168)	81·9
Docked	–7·250	(1·598)	2·367	(0·375)	58·7	3·220	(0·099)	1·994	(0·370)	50·9

† All relationships are significant ($P < 0{\cdot}05$) except those between $\log_{10}$ PKF and $\log_{10}$ MEI, and $\log_{10}$ CF and $\log_{10}$ CCW.

CCW and MEI. This was especially the case for PKF and CF.

Chemical composition of the soft tissue

The proportions of moisture, EE, CP and ash were not significantly different ($P > 0{\cdot}05$) for the undocked and docked lambs at the lower range of MEI (0·309 to 0·367 MJ/kg $M^{0{\cdot}75}$ per day; Table 7). The moisture content was significantly greater ($P < 0{\cdot}001$) and the fat content was significantly lower ($P < 0{\cdot}001$) in undocked lambs given food at the higher levels of MEI between 0·878 to 1·149 MJ ME per kg $M^{0{\cdot}75}$ per day. The protein content of the undocked lambs was also significantly higher at MEI between 0·443 and 0·522 ($P < 0{\cdot}05$) and between 0·878 and 1·149 ($P < 0{\cdot}001$) MJ ME per kg $M^{0{\cdot}75}$ per day. However, the difference in crude protein content between the two groups was not significant ($P > 0{\cdot}05$) at MEI 0·309 to 0·367 and 0·743 to 0·823 MJ ME per kg $M^{0{\cdot}75}$ per day. Ash content was not significantly affected by docking or MEI. Docked lambs had proportionately 0·073 more chemical fat than undocked lambs and only proportionately 0·02 less protein.

Discussion

Food intake and growth of lambs

Results of the present experiment showed no effect of tail docking on pre-weaning growth of lambs. This is in close agreement with earlier work of

Table 7 *Effect of tail docking on chemical composition of the soft tissue of lambs given graded levels of metabolizable energy (ME)*†

	ME intake‡ (MJ/kg $M^{0{\cdot}75}$ per day)			
Chemical composition	0·309 to 0·367	0·443 to 0·522	0·743 to 0·823	0·878 to 1·149
Moisture				
Undocked	620	588	525	517
Docked	618	488	465	470
Significance		***	($P < 0{\cdot}09$)	***
EE				
Undocked	162	225	295	307
Docked	184	343	377	374
Significance		***	($P < 0{\cdot}08$)	***
CP				
Undocked	207	177	171	166
Docked	187	160	149	146
Significance		*	($P < 0{\cdot}09$)	***
Ash				
Undocked	11	10	9	10
Docked	11	9	9	10
Significance				

† Chemical components are expressed as g/kg dry matter of the pooled soft tissue of the right carcass half; EE = ether extract, CP = crude protein.

O'Donovan *et al.* (1973) on Kellakui fat-tailed sheep in Iran and Alkass *et al.* (1985) on Awassi lambs in Iraq. Similarly, results of the present experiment showed that tail docking had no effect on post-weaning performance of lambs given moderate to high levels of ME (≥ 0·743 MJ/kg $M^{0·75}$ per day), as in earlier work by Joubert and Ueckermann (1971), O'Donovan *et al.* (1973) and Alkass *et al.* (1985). However, previous work with Awassi lambs by Farhan *et al.* (1969) showed that docking decreased daily gain, dressing percentage, the percentage of fat in the carcass and carcass weight as a proportion of empty body weight. In the present study, post-weaning growth of docked lambs given MEI levels of ≤ 0·522 MJ/kg $M^{0·75}$ per day was significantly lower ($P < 0·05$) than that of the undocked lambs. This indicates some complementary supply of energy from the tail and emphasizes the rôle of fat-tail reserves under harsh feeding conditions.

Food intake in the present experiment was not affected by tail docking and docked lambs on the high levels of MEI (≥ 0·743 MJ ME per kg $M^{0·75}$ per day) had a similar intake to undocked lambs despite their lower body fat content. Therefore, the amount of total fat in Awassi sheep does not reduce food intake despite the fat mass of the tail being an important part of the metabolic pool and probably the most readily mobilized pool. It seems that the tail fat triggers different signals than those caused by the adipose tissues of other sites. This must be an important characteristic of fat-tailed sheep and an essential element for their survival, allowing excess energy to be deposited in the tail.

Metabolizable energy requirements for maintenance and growth

It was anticipated that docking would result in lower ME requirements due to lower fat deposition but results of this study showed that the apparent ME requirements of the docked lambs were not greatly affected by the removal of the fat tail. The predicted ME requirements tended to be greater for the docked lambs at lower growth rates (≤ 100 g/day) and lower for growth rates between 100 and 225 g/day. The calculated ME requirements for maintenance for the undocked lambs in the present study were similar to those calculated by Agricultural and Food Research Council (1990) for growing sheep (0·25 MJ/kg $M^{0·75}$ per day) and Al Jassim *et al.* (1996) for the same breed of lambs of similar age and on a similar feeding regime. The calculated ME requirement for maintenance was slightly higher for the docked lambs indicating that there was some energy transferred from the tail of the undocked lambs.

Chemical composition of the soft tissue

In the present experiment the increase in chemical fat in the docked lambs was 40 and 26% of the fat normally deposited in the tail for MEI levels of 0·743 to 0·823 and 0·878 to 1·149 MJ ME per kg $M^{0·75}$ per day respectively. The increase in percentage of the chemical fat is partly attributed to an increase in the inter- and intra-muscular fat. However, at the highest levels of ME intakes (≥0·743 MJ ME per kg $M^{0·75}$ per day) deposition of fat over the caudal region was also significantly greater, but that was included with the soft tissue. Adding OF, PKF and CF to chemical fat in the present experiment gives results that agree with O'Donovan *et al.* (1973) who reported that less than 50% of the fat normally deposited in the tail was relocated as subcutaneous plus intermuscular and internal fat in docked lambs.

In conclusion, removal of the tail reduces total carcass fat, increases chemical fat of the soft tissue but does not alter ME requirements for gain, growth rate or food conversion efficiency in growing Awassi fat-tail lambs.

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