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Effect of Docking and Diet Energy on Carcass Fat Characteristics in Fat-Tailed Baluchian Sheep

Ali MOHARRERY

Animal Science Department, Agricultural College, Shahrekord University, P.O. Box 115, Shahrekord - IRAN

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Abstract: Effects of docking on carcass fat characteristics were studied in fat-tailed sheep. Male lambs were randomly divided into 2 groups. One group was docked after birth using rubber rings, and the tails of the other group were left intact (control). After weaning, 20 lambs from each group were divided into 2 subgroups; one subgroup was fed with a normal energy diet (10.25 MJ/kg ME) and the other one with a high-energy diet (11.42 MJ/kg ME) for 84 days. At the end of the fattening period, 28 lambs were slaughtered for determination of warm carcass weight (WCW) and other carcass characteristics. At 24 h postmortem samples of meat, omental fat, and caudal fat were taken from chilled (4 °C) carcasses for the assessment of fatty acid (FA) composition. No significant difference ($P > 0.05$) was observed in WCW and omental fat between carcasses of docking and control lambs, but lambs on 2 types of energy diets showed a significant difference ($P < 0.05$). Under these circumstances, docked lambs produced leaner carcasses than intact lambs ($P < 0.05$). Diet energy had a significant effect on average daily gain and daily feed intake ($P < 0.05$). Results showed that the predominant FA in body fat was oleic acid and a significant difference was observed for percentage of FA composition between fat in different parts of body ($P < 0.05$).

Key Words: Baluchian sheep, docking, carcass characteristics, fatty acid composition

Introduction

Baluchian sheep have a particular characteristic of having more reserve fat around the coccygeal vertebrae. For this reason they are classified as fat-tailed sheep. Adipose tissue in ruminants is the principal site for the de novo synthesis of long-chain fatty acids and a major site for the production of the monounsaturated fatty acyl-CoA esters. The lipids in the subcutaneous and intermuscular fat are mostly made up of triacylglycerol with basically phospholipids in intramuscular fat but the amount of triacylglycerols depends on the amount of marbling in the muscles (1). Ruminant animals in general, and sheep in particular, have relatively high ratios of saturated: monounsaturated fatty acids in their lipids (2), which are consumed by humans as meat (principally due to adipose tissue infiltrating skeletal muscle) and milk products. Lamb fat is solid and very saturated. The melting point of lamb fat varies depending on the location on the carcass and the type of feed, age at slaughter, and breed (3).

Energy and protein supplements fed to improve the growth rate of pasture-based lambs affect energy intake and partitioning of energy retained (4,5). Measurement of the amount of external fat is an important factor for grading of carcasses. On the other hand, docking of fat-tail can help to reduce fat in lamb carcasses (6-9).

The objectives of this study were to examine the effects of docking and 2 dietary energy supplements on intake, carcass weight, fat depth, caudal fat, omental fat, and muscle fatty acid compositions in fat-tailed Baluchian sheep. Each diet was fed to docked and undocked lambs.

* E-mail: ali.moharrery@agrsci.dk

Since no attempt has been made in the past to characterize the correlation between the fatty acids in the adipose tissue in fat-tailed breeds, one of the objectives of this experiment was to tentatively characterize the major types of fatty acids and to determine the correlation between them.

Materials and Methods

Animals and care

Soon after parturition, male lambs were randomly divided into 2 groups. One group was docked 3-4 h after birth using rubber rings and the tails of the other group were left intact (control). After weaning, 20 lambs from each group were divided into 2 subgroups, one subgroup was fed with normal energy diet (10.25 MJ/kg ME) and the other one with high-energy diet (11.42 MJ/kg ME), in a 2 × 2 factorial design for 84 days (Table 1). Feed samples were analyzed for crude protein (Kjeldahl method), neutral detergent fiber (NDF), and acid detergent fiber (ADF) according to Van Soest et al. (10). Lambs were housed in individual pens and had free access to water. At the end of the feeding trial, 28 (7 from each group) lambs were slaughtered for determination of carcass characteristics. After slaughtering, carcasses were chilled at 4 °C for 24 h and were split into different retail cuts. Longissimus dorsi muscle in between the 12th and 13th ribs and fat thickness on this muscle were measured with caliper apparatus. Half of each carcass was mechanically deboned and minced. After homogenizing each half side, sub-samples were collected and analyzed for water (air oven method ID 925.10), protein (copper catalyst Kjeldahl method ID 984.13), fat (solvent extraction method ID 991.36), and ash (ID 923.03) content (11). Samples of meat, omental fat, and caudal fat stored at –80 °C for future analyzes including physical characteristics and fatty acid composition.

Table 1. Ingredients and nutrient composition of the experimental diets.

	Rations	
	Normal Energy	High Energy
Dietary components (%)		
Alfalfa hay	27	16
Barley straw	17	11
Barley grain	20	32
Corn grain	7	11
Beet pulp	11.6	10
Cotton seed meal	9.4	8
Wheat bran	6	10
Limestone	0.5	1
Salt	0.9	0.6
Vitamin and mineral mixture	0.6	0.4
Nutrient composition (% DM)		
Dry matter[2]	89	89
ME (MJ/kg)[1]	10.25	11.42
CP[2]	14.5	14.5
NDF[2]	41.6	35.3
ADF[2]	26.6	20.2
Ca[1]	0.76	0.76
P[1]	0.39	0.46

DM = Dry matter; ME = Metabolizable energy; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; Ca = Calcium; P = Phosphorus.

[1] Calculated according to NRC (*) for diet component. Energy converted to the MJ unit.

[2] Analyzed in nutrition laboratory.

* NRC.: Nutrient Requirements of Sheep. Sixth revised edition. National Academy Press. Washington. D.C., 1985.

Determination of melting-point and refractive index

For measurement of melting point, each sample was placed in a capillary, heated at a controlled rate. A special instrument (Electrothermal IA9100) controlled the heating at the rate of 1–2 °C/min. The refractive index of the sample was measured with a refractometer using a monochromatic light source, after a successful retest with the laboratory control standards at 40 °C.

Determination of fatty acid composition

The fat sample was extracted by the method of Folch et al. (12), using a chloroform/methanol mixture (v:v 2:1). Fatty acids were converted to methyl esters by base-catalyzed transesterification and any free acid in the fat was esterified by a subsequent reaction with BF3/CH3OH. The methyl esters were analyzed by gas chromatography on an Omegawax 320 capillary column; 30 m x 0.32 mm ID fused silica (Supelco, Bellefonte, PA, USA). Injector and detector temperatures were 300 °C and 310 °C, respectively. The column was programmed as follows: 160 °C for 2 min then raised to 210 °C at the rate of 3 °C/min, and this temperature was then maintained for 10 min. Peaks were identified using standards, and the results were expressed for each fatty acid as a percentage of the total fat extracted.

Statistical analysis

The completely randomized design model was used to analyze data for weight gain, feed intake, and feed

conversion. In this regard, in a 2 x 2 factorial design (2 treatments for docking or intact group and 2 energy levels for diets), 4 treatments in 10 replicates were set-up. For carcass characteristics, treatments were replicated 7 times per diet (n = 7) in both docked and intact groups. The data were analyzed using the general linear model procedure of SAS (13). In some cases, the initial weight or warm or cold carcass weights were used as a covariant in the model if they were significant (P > 0.05); otherwise, they were omitted. The correlation among fatty acids was determined and correlation coefficients were tested using a t-test (13).

Results

Animal performance

Effects of different treatments on animal performance are presented in Table 2. Docking resulted in no difference in daily weight gain (P > 0.05) compared with intact lambs. Feeding of high-energy diet resulted in 22% higher daily gain (P = 0.0235) for lambs on this type of ration compared to the normal energy diet.

There was no difference (P > 0.05) between types of operation for daily feed intake. In this regard, feed intake in lambs on high-energy diet was 18% higher compared to lambs on normal energy (P = 0.0001). There was no difference (P > 0.05) between treatments regarding feed conversion; however, a significant difference (P = 0.0337) was observed in the interaction between ration and docking operation in feed intake (the values for the intact group on normal and high energy diet are 1.246 and 1.417 kg/day, respectively, and for the docked group on normal and high energy diet are 1.210 and 1.499 kg/day, respectively).

Carcass parts and meat analysis

The data for carcass parts are presented in Table 3. There was no difference between treatments in warm

Table 2. Lamb performance under different treatments.

Item	Operation		Energy of diet			Probability		
	Intact	Docked	Normal	High	SE	O	D	O × D
Daily gain (g)	138	155	132	161	8.21	0.1633	0.0235	0.2327
Daily Feed intake (kg)	1.333	1.352	1.231	1.454	0.020	0.4723	0.0001	0.0337
Feed conversion	10.27	9.31	9.90	9.67	0.735	0.3606	0.8308	0.2327

O = operation; D = diet; O × D = interaction; SE = standard error.

Table 3. Carcass parts for different treatments.[1]

Item	Operation		Energy of diet			Probability		
	Intact	Docked	Normal	High	SE	O	D	O × D
Live weight (kg)	42.99	41.19	40.69	43.46	0.861	0.1526	0.0352	0.2052
Warm carcass (kg)	21.48	20.97	20.54	21.91	0.292	0.5298	0.0984	0.9592
Cold carcass (kg)	21.03	20.46	20.03	21.46	0.052	0.4287	0.0115	0.0437
Omental fat (g)	1140	1232	978	1394	94.46	0.2914	0.2148	0.2287
Leg (g)	2941	3055	2931	3065	29.07	0.0001	0.2433	0.1200
Foreshank (g)	1859	1859	1823	1896	21.52	0.1119	0.1118	0.7232
L. dorsi muscle[2] (g)	1498	1564	1441	1621	35.02	0.0537	0.0929	0.1339
L. dorsi area[3] (cm^2)	14.76	16.28	14.73	16.31	0.632	0.0987	0.1017	0.6133
Fat thickness[4] (mm)	6.13	5.44	4.84	6.73	0.655	0.4157	0.0444	0.5027
Caudal fat (g)	2672	1363	1952	2083	122.4	0.0001	0.5838	0.2758

O = operation; D = diet; O × D = interaction; SE = standard error.

[1] Warm carcass adjusted for lamb weight, cold carcass and omental fat adjusted for warm carcass weight, and other parameters adjusted for cold carcass weight.

[2] Vertebral column plus longissimus dorsi muscle.

[3] Area of longissimus dorsi muscle located between 12^{th} and 13^{th} ribs.

[4] Fat thickness on longissimus dorsi muscle located between 12^{th} and 13^{th} ribs.

carcass traits (P > 0.05). The docked lambs showed superiority for high price cuts (leg and longissimus dorsi muscle) compared to intact lambs (P < 0.05). There was a significant difference between means of caudal fat, but there was no difference in terms of diet energy. There were no differences in means of all cuts except for cold carcass weight and fat thickness on the 12th rib in both levels of energy in diets (P > 0.05). Significant interactions between diet energy and operation were observed only for cold carcass weight (the values for intact group on normal and high energy diets are 20.29 and 21.78 kg, respectively, and for the docked group on normal and high energy diets are 19.76 and 21.15 kg, respectively).

The results for meat analysis and total fat in carcass lambs are presented in Table 4. No difference (P < 0.05) was observed between treatments in terms of the chemical analysis of the meat samples. There was a significant interaction (P < 0.05) between diet energy and docking operation in terms of moisture, protein, and fat percentage. Calculated percentage and total grams of fat in the carcasses showed that the docking decreased the fat content in carcasses as a percentage or grams, and increasing dietary energy resulted in more fat deposition (P < 0.05). In this regard, a significant interaction was observed between docking operation and energy diets for the total fat content in carcasses (the values for the intact group on normal and high energy diets are 32.79% and 34.44%, respectively, and for the docked group on normal and high energy diets are 28.30% and 34.32%, respectively).

Fatty acid composition

Melting point, refractive index, and fatty acid compositions of 3 types of body fat are presented in Table 5. Melting point and refractive index for meat fat and caudal fat numerically decreased when lambs were docked or were given the high-energy diet (Table 5). However, the reverse trend was found for omental fat, where melting point and refractive index increased with docking lambs or lambs on the high-energy diet (P < 0.05). Lambs on the high-energy diet reduced the linoleic acid percentage in meat fat (P < 0.05). In contrast to this dissimilarity, no difference was found between treatments for meat fat. Linolenic acid was only found in lambs on the normal energy diet. In this regard, linolenic acid was found in caudal fat in intact lambs, but this type of fatty acid was found in omental fat in docked lambs. There was a higher percentage of myristic acid in lambs on the high-energy diet compared to those on the normal-energy diet for caudal fat (P < 0.05), whereas no difference was observed for fatty acid composition, other than myristic acid. A significant difference was observed for omental fat. A higher percentage of myristic acid was found for docked lambs and lambs on the high-energy diet (P < 0.05). The high-energy diet increased the palmitic acid percentage in omental fat (P < 0.05). The reduction in linoleic acid percentage for docked lambs in the omental fat fraction was highly significant (P = 0.0015). There was no interaction between operation and energy of diet for fatty acid composition in all 3 types of fat.

Table 4. Chemical analysis of meat sample (as-is basis).

Item	Operation		Energy of diet			Probability		
	Intact	Docked	Normal	High	SE	O	D	O × D
Moisture (%)	57.52	56.15	57.54	56.12	0.747	0.2045	0.1912	0.0566
Protein (%)	13.64	14.37	14.42	14.58	0.241	0.4389	0.6322	0.0202
Ether extract (%)	26.02	27.75	26.27	27.49	0.913	0.1914	0.3540	0.0285
Ash (%)	0.83	0.74	0.76	0.80	0.039	0.1138	0.5210	0.4127
Total fat (%)[1]	33.61	31.31	31.37	33.56	0.785	0.0487	0.0603	0.0021
Total fat (g) [1]	7480	6817	6607	7691	289.4	0.1185	0.0140	0.0390

O = operation; D = diet; O × D = interaction; SE= standard error.

[1]: In whole carcass.

Table 5. Physical characteristics and fatty acid composition in different types of fat samples.

Item	Operation		Energy of diet			Probability		
	Intact	Docked	Normal	High	SE	O	D	O × D
Meat fat								
Melting point (°C)	39.21	38.00	38.95	38.26	0.491	0.4141	0.0829	0.9783
Refractive index	1.4586	1.4587	1.4585	1.4587	0.00013	0.0933	0.3335	0.7146
Fatty acid composition (%)								
14:0	5.80	5.83	5.48	6.21	0.397	0.5676	0.1523	0.1195
16:0	29.18	30.79	30.54	29.46	1.838	0.6288	0.6525	0.5023
18:0	10.58	11.01	11.00	10.59	0.615	0.9233	0.4364	0.4064
18:1	50.85	48.72	49.01	50.51	2.615	0.6767	0.6351	0.6097
18:2	3.60	3.65	3.97	3.23	0.230	0.8875	0.0341	0.3427
SFA	45.55	47.63	47.02	46.26	2.450	0.6661	0.7662	0.6489
UFA	54.45	52.37	52.98	53.74	2.450	0.6661	0.7662	0.6489
SFA/UFA	0.837	0.909	0.888	0.861	0.248	0.5189	0.4801	0.4858
Caudal fat								
Melting point (°C)	34.24	32.80	34.64	34.40	0.643	0.2925	0.6309	0.4521
Refractive index	1.4583	1.4585	1.4585	1.4584	0.00017	0.1256	0.0212	0.5874
Fatty acid composition (%)								
14:0	5.70	6.54	5.63	6.73	0.347	0.2368	0.0244	0.2190
16:0	30.41	28.16	29.90	28.43	2.004	0.5277	0.5524	0.3459
18:0	9.21	9.14	9.29	9.05	0.683	0.8196	0.7926	0.8208
18:1	51.25	53.08	51.92	52.58	2.700	0.6001	0.8450	0.5640
18:2	3.32	3.07	3.16	3.21	0.152	0.4020	0.7821	0.2240
18:3	0.12	0.00	0.10	0.00	0.059	0.8041	0.1703	0.1321
SFA	45.32	43.85	44.82	44.21	2.650	0.5568	0.8541	0.6289
UFA	54.68	56.15	55.18	55.79	2.650	0.5568	0.8541	0.6289
SFA/UFA	0.829	0.781	0.812	0.729	0.267	0.8950	0.4957	0.3874
Omental fat								
Melting point (°C)	45.46	46.10	45.61	45.95	0.404	0.5399	0.0258	0.5844
Refractive index	1.4582	1.4580	1.4578	1.4584	0.00007	0.2774	0.5628	0.9507
Fatty acid composition (%)								
14:0	5.87	6.77	6.25	6.52	0.183	0.0001	0.0001	0.0051
16:0	30.75	31.11	30.39	31.45	0.377	0.4495	0.0378	0.1112
18:0	20.23	19.36	19.91	19.54	0.436	0.0751	0.1585	0.5943
18:1	38.46	38.63	39.08	38.12	0.675	0.8563	0.3046	0.7311
18:2	4.69	3.98	4.18	4.35	0.206	0.0015	0.1076	0.5059
18:3	0.00	0.15	0.19	0.00	0.141	0.2250	0.9179	0.1544
SFA	56.85	57.23	56.55	57.52	0.637	0.5226	0.1154	0.7940
UFA	43.15	42.77	43.45	42.48	0.637	0.5226	0.1154	0.7940
SFA/UFA	1.323	1.347	1.312	1.359	0.035	0.4676	0.1461	0.7697

O = operation; D = diet; O×D = interaction; SE = standard error; SFA = saturated fatty acids; UFA = unsaturated fatty acids.

To compare between fatty acid compositions in all 3 types of fat (meat fat, caudal fat, and omental fat), all the data were pooled and are presented in Table 6. The omental fat had the highest percentage of saturated fatty acid (SFA) and the lowest value was found for the caudal fat ($P < 0.05$). Corresponding to this trend the lowest percentage of unsaturated fatty acid (UFA) belonged to omental fat and the highest value was related to caudal fat ($P < 0.05$). The value for meat fat was intermediate and showed significant difference with 2 types of fats ($P < 0.05$). However, the linoleic percentage was highest in omental fat compared with other types ($P < 0.05$). The lower percentage of oleic acid ($P < 0.05$) in omental fat caused a reduction in unsaturated fatty acid percentage in this type.

Correlation between fatty acids

The data from all treatments were pooled for each type of fat and correlation coefficients with significance levels related to these data are shown in Table 7.

Table 6. Percentage of fatty acid composition in different types of fat.

	Meat	Caudal	Omental	SE
Fatty acid composition (%)				
14:0	5.82	6.15	6.40	0.307
16:0	30.04	29.21	30.96	1.197
18:0	10.81 [b]	9.18 [c]	19.71[a]	0.485
18:1	49.70 [a]	52.23 [a]	38.56 [b]	1.632
18:2	3.63 [b]	3.18 [c]	4.27 [a]	0.200
SFA	46.67 [b]	44.54 [b]	57.07 [a]	1.568
UFA	53.33 [a]	55.46 [a]	42.93 [b]	1.568
SFA/UFA	0.99 [b]	0.92 [b]	1.34 [a]	1.087

SE: standard error; SFA = saturated fatty acids; UFA = unsaturated fatty acids.
Means with the same letter in each row are not significantly different ($P < 0.05$).

Table 7. Correlation coefficient between percentage of different fatty acids.[1]

Item	Fat (g)	Fatty acids(%)				
		14:0	16:0	18:0	18:1	18:2
Fat (g)	1.0000 [a] (.0000 [b])	-0.0518 (0.6181)	-0.1470 (0.1550)	-0.5675 (0.0000)	0.4458 (0.0000)	-0.2715 (0.0078)
14:0		1.0000 (.0000)	0.1858 (0.0715)	0.0821 (0.4289)	-0.2693 (0.0083)	-0.2738 (0.0073)
16:0			1.0000 (.0000)	0.3168 (0.0018)	-0.7840 (0.0000)	0.2473 (0.0157)
18:0				1.0000 (.0000)	-0.8220 (0.0000)	0.5672 (0.0000)
18:1					1.0000 (.0000)	-0.5226 (0.0000)
18:2						1.0000 (0.0000)

[1] All data from 3 fractions (meat, caudal and omental fats) were pooled.
[a] Coefficient of correlation.
[b] Significant level.

The highest negative significant correlation was observed between oleic acid and stearic and palmitic acids ($P < 0.0001$). On the other hand, a highly positive and significant correlation was observed between linoleic and stearic acids ($r = 0.5672$; $P < 0.0001$). In the pooled data it was best to use the coefficient of determination (r^2) to explain the degree of association between 2 variables. In this regard, the r^2 calculated for oleic with stearic and palmitic acids are 0.6757 and 0.6147, respectively. These amounts signify that 67.6% and 61.5% of total variation in oleic acid can be explained by the relationship between oleic acid and the amount of stearic and palmitic acids, respectively. In this manner, the coefficient of determination for palmitic and stearic acids is 0.100.

Discussion

Fat-tailed sheep are probably more tolerant to feed shortages prevalent in most parts of Asia compared to the European breeds. The hardiness of fat-tailed sheep in this area is most likely due to the storage of fat in their tails during the lush season, which can be used up during frequent long periods when plant growth is dormant or in drought years (9). In Table 2 the average daily gain was similar in the docked and intact lambs. In agreement with the present study, O'Donovan et al. (14) reported non-significantly higher final body weight values in docked than in undocked lambs during the fattening period in Kallakui lambs. Generally, weight gain was higher in the lambs on high-energy diets than in those on normal-energy diets. These results are in agreement with those reported by Fluharty and McClure (15). The higher daily weight gain resulted from higher daily feed consumption in the form of dry matter in the lambs on the high-energy diet. O'Donovan et al. (14) and Marai et al. (8) reported similar trends during the fattening period in docked and undocked Kallakui lambs, Dubasi (Sudan desert) sheep, and Ossimi sheep.

However, the results of the present study for carcass trait are in contrast with those of Epstein (6) and Joubert and Uckermann (7), who showed that docking decreased the carcass weight. The trend towards heavier prime cuts in the docked than in the intact animals (Table 3) is similar to the results of Juma et al. (16). In the docked lambs, fat-tail, a main part for storage of fat, was removed and thus other fat depots such as intermuscular and intramuscular fat can compensate for part of fat storing up to their potential. Hypertrophy of adipose cells in these depots might be a main factor for increasing weight of leg and loin area as prime cuts of carcass. Nevertheless, although the heavier prime cuts might be interpreted as a possibility of change in body fat metabolism, no conclusion could be drawn from these data.

The meat sample, excluding the caudal fat, showed significant higher dry matter and ether extract along with lower protein percentage in the docked lambs on the high-energy diet compared to the intact lambs on the same ration (Table 4). It might be also postulated that part of the fat in the docked group might store extra marbling. The meat sample of lambs on the high energy-diet showed the same results as their counterparts. Estimated percentage and total grams of fat in the carcass soft tissues including the caudal fat in the lambs on high-energy diet indicated that the increased weight gain and carcass weight resulting from increased dietary energy intake were largely due to more fat deposition. In this regard, energy supplements fed to improve growth rate of pasture-based lambs affect energy intake and partitioning of energy retained (4,5).

The lower fat as a percentage of carcass weight or grams in the docked group (Table 4) may indicate that the potential for fat synthesis and deposition in the body is limited to the fat tissue. When the main organ for fat deposition is removed physically, as other organs have a limited potential to compensate for fat storage compared to fat-tail, the omental, subcutaneous, and muscular fat will show some degree of hypertrophy. A 2.3% reduction in total body fat in the docked lambs (Table 4) can be explained as a limitation of other fat tissues in the body for storing fat. Sefidbakht and Ghorban (9) reported that the docked lambs reduced the total separated fat by 11.25% compared to the intact group. The present study showed that the carcasses of docked lambs have 2.3% lower fat compared to the carcasses in the intact groups. The difference between this result and the one reported by Sefidbakht and Ghorban (9) is due to different fat measurement methods used. Sefidbakht and Ghorban (9) used a physical method (excluded intramuscular fat) while a chemical method (included intramuscular fat) was used for separation of fat in carcasses in the present study.

Except omental fat, the ratio of SFA:UFA is less than 1 (Table 5) in other types of fat, which is in contrast to the findings of the study performed by Christie (2), who reported that ruminant animals in general, and sheep in particular, have a high ratio of saturated: monounsaturated fatty acids in their adipose tissue lipids. This arises from a variety of factors. Dietary fatty acids are usually polyunsaturated, although they are hydrogenated by ruminal microorganisms. Additionally, because ruminant diets have a relatively low fat content, there is a high rate of de novo fatty acid synthesis in the adipose tissue (17). Therefore, phenotypic variation in the monounsaturated fatty acid composition of adipose tissue depots is primarily due to site-specific differences in fatty acid metabolism. In contrast to carcass and epicardial adipose tissues, stearoyl-CoA desaturase (SCD) gene expression did not vary significantly with adipocyte cell volume in the abdominal depots (18). This is likely to be a major factor responsible for the low ratio of C18:1:C18:0 of the abdominal depot compared with carcass depots or caudal fat in fat-tailed sheep.

Three main fatty acids (C16:0, C18:0, and C18:1) represent the major part (on average 90%) of the total fatty acid composition in meat, omental, and caudal fat (Table 5). This is consistent to that which has been reported by other researchers (19). The meat and omental fat in lambs, ewes, and rams did not contain measurable quantities of C20 and C22 polyunsaturated fatty acids. This is probably due to the low proportion of phospholipid in the adipose fraction and the failure of ruminant adipose tissue to incorporate these fatty acids into the triacylglycerols, despite the fact that they are not hydrogenated by the rumen (20).

A Greek study on suckling lambs slaughtered at 6-weeks old showed a difference in melting point and fatty acid composition of tail and perinephric fat between breeds (21). L'Estrange and Hanrahan (22) found a difference between breeds in melting point in subcutaneous rib fat that was explained by a difference in C18:0 and C18:1. C18:0 decreased and melting point fell with increased carcass weight. In the present study some significant differences were observed between treatments in fatty acid contents attributed to the 3 fat types (linoleic in meat and omental fat and myristic in caudal, and omental fat). In this regard, Crouse et al. (23) did not find differences in fatty acid content attributed to carcass weight, which was associated with increasing quantities of fat. A study in Wyoming, USA, showed that no significant difference was detected for the melting point of wether fat (24).

In the present study, the ratio of oleic to stearic acid in the omental, meat, and caudal fats was 1.96, 4.60, and 5.69, respectively (Table 5). The reason for these tissue-specific differences could be the lower oleic acid concentration in the omental fat compared with the meat fat and especially caudal fat, along with higher percentage of stearic acid in corresponding types.

Table 5 shows that meat and caudal adipose tissue contain less stearic acid and more oleic acid than the omental adipose tissue depots, which is in agreement with findings of Barber et al. (18), who reported that subcutaneous adipose tissue contains less stearic acid and more oleic acid than the internal adipose tissue depots.

Since the elongation of palmitic acid produces stearic acid and the precursor for synthesis of oleic acid is stearic acid, the highest negative correlation was detected between percentage of stearic acid and oleic acid, and simultaneously a positive correlation between 16:0 and 18:0 and negative correlation between 16:0 and 18:1 fatty acids (Table 7). This is because the preferred substrate of SCD is stearic rather than palmitic acid. On the other hand, a strong and positive correlation between SCD mRNA and oleic acid content of sheep tissues was reported (25).

With respect to the strong significant correlation between total body fat as a gram value with stearic ($r = -0.5675$; $P < 0.0001$) and oleic ($r = 0.4458$; $P < 0.0001$) acids as a percentage value (Table 7) and whatever explained earlier the relationship between stearic and oleic acids, this possibly explains the significant overlapping function among metabolic pathways, which produce fatty acids with 18 carbon atoms and desaturase enzymes in these process.

The significant correlation between total fat with 18:0 and 18:1 fatty acids in the present study is in contrast to the findings of Daniel et al. (25). In fat-tailed sheep, the main place for storing fat is the caudal area around the coccygeal vertebrae.

In conclusion, it is postulated from the results of this study that docking of Baluchian lambs after birth did not influence feed consumption, but improved meat quality and amounts of high price carcass cuts, and reduced total fat content as a percentage of the whole body. Energy of diets had an effect on average daily gain and daily feed

intake. There was an interaction between docking and diet energy in this study although effects in some cases were non-additive. Docking of Baluchian lambs did not influence their fatty acid profile in the meat-fat tissue, but improved most of the fattening parameters, which is recommendable for the sheep production industry.

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