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Carcass traits of Rambouillet and Merino × Rambouillet lambs and fatty acid profiles of muscle and subcutaneous adipose tissues as affected by new sheep production system

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Abstract

Rambouillet and Merino×Rambouillet lambs were assigned to production systems varying in physical environment and diet: RF (raised-floor, open-sided barn/85% oat hay–10% wheat–5% molasses), FL (feedlot/high-concentrate), and P (pasture/grazing plus supplement). Although treatment duration was varied to produce similar final weights, RF lambs were heavier than P lambs, but dressing percentages were similar. Backfat thickness was less with P and for Merino cross lambs. RF feed was higher in saturated fatty acids (SFA) percentage than FL feed and P supplement, but lower compared to pasture plants. For both breed types, muscle tissue from RF was higher in SFA and lower in polyunsaturated fatty acids (PUFA) percentage than that from FL or P. In adipose tissue, SFA and PUFA tended to be higher and monounsaturated fatty acids were lower with RF for Merino cross lambs. Nevertheless, 16:0 or 18:1 percentage differences among P, FL and RF lamb tissue samples were minor vs. large variations among their respective diets.

Keywords: New sheep production system; Fatty acids; Muscle tissue; Adipose tissue; Carcass traits

1. Introduction

Lambs and, to a lesser extent, goats traditionally have been "finished" in feedlots or a pasture (or range) situation. Because of the inherent dustiness and/or muddiness of most commercial feedlots and the requirement to maximize daily gains, it is difficult to produce clean, high-value fibers with animals fed in these types of facilities. In an attempt to produce distinctly high-value fibers from lambs and goats, a special, covered feeding facility with open sides was recently constructed at the Texas A&M University Agricultural Research and Extension Center at San Angelo. The main feature of the facility was a raised/slatted wooden floor—slatted to release fecal material and urine, and raised (107 cm above ground) to facilitate removal of manure and provide adequate ventilation. Feeding and watering systems were so designed that all animals would have equal and adequate access to feed and water without contaminating them with fecal material or urine, and the labor requirement would be low. As the animals in such a covered/confined feeding facility would have less physical activity than even those in a feedlot, they were to be fed a special ration (lower in energy density as compared to typical feedlot/high-concentrate rations), so that they would not become too heavy before achieving sufficient (> 9.5 cm) fiber growth. We hypothesized that the meat resulting from such a production system (entailing both dietary and physical environment differences) would differ in quality traits, including carcass traits and fatty acid profiles of tissue lipids, when compared to the traditional production systems. The fatty acid composition of meat can affect product storage stability (thus flavor) and also is an important diet/health concern to consumers. It has been shown that fatty acid profiles of ruminant tissues can be influenced by animal production system or nutritional background (Larick & Turner, 1989; Marmer, Maxwell, & Williams, 1984; Rhee, 2000; Rhee, Ziprin, Bishop, & Waldron, 1997; Rowe, Macedo, Visentainer, Souza, & Matsushita,

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1999). The production systems evaluated and compared to date have included a feedlot system (animals being placed in a feedlot and fed a grain-based ration) and a pasture system (animals being given access to a pasture or rangeland for grazing, with or without supplemental feed). We have conducted research to compare our new production system to the traditional (feedlot and pasture) production systems for effects on wool production, animal performance (rate of gain), carcass properties, and fatty acid profiles of intramuscular (IM) and subcutaneous (SC) fat. This report is concerned only with the carcass properties and fatty acid profiles.

2. Materials and methods

2.1. Materials

Rambouillet and Merino × Rambouillet lambs (wethers) were used in this study, and lambs were raised in San Angelo, Texas. Rambouillet lambs were obtained from two sources: from Texas Agricultural Station-registered and non-registered flocks and from a commercial feedlot in Texas. All lambs were selected for uniformity in size and appearance and are considered to be highly representative of Rambouillet wether lambs in Texas. The Merino cross lambs were from a single private source in Nevada.

Lambs (about 4 months of age) were first placed on a uniformity diet (diet No.1 in Table 1) for 3 weeks. Subsequently, each lamb (20/breed type/treatment, blocked by liveweight; a total of 120 lambs) was assigned to one of three production systems: animals being placed in an open-sided barn with raised/slatted floor and fed a pelleted mixture of oat hay (85%)–wheat (10%)–molasses (5%) (production system designated as RF); animals being placed in a feedlot and fed typical step-up/high-concentrate rations (production system designated as FL); and animals being given access to a pasture (rangeland) with supplemental feed provided after 11 weeks in the pasture (production system designated as P). Table 1 shows compositions of FL-lamb diets and P-lamb supplements. The production treatments started in June 1999. Pasture plant samples were obtained toward the end of the P treatment period (close to the slaughter time of P lambs). The parts of each plant that P lambs were expected to have consumed were cut with scissors, placed in plastic bags, and frozen. It should be noted that vegetation produced on the rangeland during the treatment period was insufficient due to drought, thus a high proportion of the diet consumed by P lambs consisted of the supplement supplied to them. Nevertheless, P lambs had more physical activity than FL or RF lambs, as they walked several miles each day while grazing and returning to water.

Days to slaughter (or treatment duration) were aimed at production of a ~59-kg shorn final weight. Slaughter and carcass evaluations were conducted in San Angelo at the Ranchers Lamb of Texas commercial slaughter facility. At ~24 h postmortem, each carcass was ribbed at 12th and 13th rib interface. Backfat thickness was measured over the center of the ribeye between the 12th and 13th ribs, and bodywall thickness was measured at ~2.54 cm below the ribeye. Carcasses were also evaluated for yield grade (USDA, 1992) by professional USDA-employed graders.

During carcass evaluation, small amounts (>20 g each) of *semimembranosus* muscle and adjacent subcutaneous fat layer were removed from each carcass, double-bagged in Ziploc® freezer bags, and frozen. The lamb tissue samples, pasture plant samples, and representative samples of the RF-lamb diet, the finishing diet for FL lambs (diet No.3, Table 1), and the finishing supplement given to P lambs (supplement No.2, Table 1) were transported frozen to College Station. Upon receiving, the lamb tissue samples were individually vacuum-packaged, whereas the diet samples were double-bagged

Table 1
Percentages of ingredients in the diets for feedlot lambs and the supplements for pasture lambs

Ingredient	FL diets (time fed, weeks)			P supplements (time fed, weeks)	
	Diet No.1 (1)	Diet No.2 (1)	Diet No.3 (17)	Suppl. No.1 (6)	Suppl. No.2 (24)
Sorghum grain	52.0	39.5	67.7	81.5	60.0
Dehydrated alfalfa meal	10.0	10.0	5.0	0	10.0
Cottonseed hulls	20.0	30.0	10.0	0	0
Cottonseed meal	12.0	15.0	12.0	9.0	10.0
Soybean meal	0	0	0	0	10.0
Molasses	4.0	4.0	3.0	4.5	4.0
Urea	0	0	0.5	0	0.5
Ammonium chloride	0.5	0.5	0.5	0	0
Calcium carbonate	1.0	0.5	1.0	0	0
Mono-dicalcium phosphate	0	0	0	0	1.0
Vitamin–mineral–antibiotic pre-mix	0.50	0.50	0.3	0	0.5
Salt	0	0	0	5.0	4.0

in Ziploc® freezer bags. All samples were kept at −20° C until analysis.

2.2. Analytical methods

A chloroform–methanol (2:1) mixture was used to extract total lipids as described by Folch, Lees, and Sloane-Stanley (1957). Before lipid extraction from pasture plant samples, they were cut very finely with a pair of scissors (because most of the plant samples were too fibrous to be chopped in a food processor), soaked in distilled water (30 ml/10 g sample) for 24 h at 4° C, and drained. Each of the diet/supplement samples was finely ground in a kitchen-type food processor, soaked in distilled water (30 ml/10 g sample), and drained prior to lipid extraction. It should be mentioned that the total lipid extraction procedure of Folch et al. (1957), using 2:1 chloroform–methanol mixture as the extraction medium, was developed with high-moisture biological samples, i.e. animal tissues. Since the moisture in such samples would have had a role in lipid extraction, we hydrated the plant samples, which were mostly dry by the time analyzed. To extract lipids from lamb tissues, 5-g portions of finely chopped samples were used directly.

To determine fatty acid composition, aliquots of lipid extracts were freed of solvent under a nitrogen stream and transmethylated using tetramethylammonium hydroxide in methanol (Metcalfe & Wang, 1981). Fatty acid methyl esters were analyzed using a gas chromatograph (Varian 3400) fitted with a fused silica capillary column, as described by Rhee, Ziprin, Ordonez, and Bohac (1988). Results for each fatty acid were expressed as a percentage of the sum of the peak areas of all identified fatty acids.

The Statistical Analysis System software (SAS, 1997) was used to perform data analysis. A mixed model (PROC MIXED) was used, with animal treated as a random effect. Correlation analysis (PROC CORR) was also conducted where appropriate. Significance was established at $P \leqslant 0.05$.

3. Results and discussion

Average initial weight of lambs was 34.5 kg, with no significant differences among treatments or between breed types. Final shorn weights were slightly off the ~59.0 kg target (Table 2) and were greater for RF lambs than for FL and P lambs. However, carcass weight was not significantly different between RF and FL lambs. Dressing percentage was greater for FL lambs than RF and P lambs. Results indicated that RF lambs probably had greater gut fill than the other two groups. As with carcass weight, backfat thickness, body-wall thickness, and USDA yield grade were all higher for FL and RF lambs than for P lambs, even though the supplemental feed constituted a large proportion of the diet consumed by P lambs, due to inadequate vegetation in the pasture. Such carcass trait differences of P lambs vs. FL and RF lambs might be due in part to a greater physical activity (for grazing) of P lambs in the pasture. As inferred earlier, we also observed less physical activity in the RF group vs. the FL group of lambs. As for the differences between the two lamb breeds, Merino cross exhibited lower values for all the carcass traits evaluated.

Fatty acid profiles of the finishing P-lamb supplement and FL-lamb diet, the RF-lamb diet, and pasture plant samples are shown in Table 3. Pasture plants were much higher in total saturated fatty acids (SFA) percentage compared to the FL-lamb diet and the P-lamb supplement (58–81% for pasture plants vs. 19–26% for the other two). Conversely, total unsaturated fatty acids (UFA) percentage was higher for the latter (74–81% vs. 19–42%). Accordingly, extremely large differences were observed in the UFA/SFA ratio between pasture plants and the feeds/supplement (0.24–0.72 vs. 2.59–4.62). In each feed and plant sample, except tobosagrass, a greater proportion of unsaturated acids consisted of PUFA (52–85% of total unsaturated acids, excluding tobosagrass) than MUFA (15–48% of total unsaturated acids). This is also seen in higher PUFA/SFA ratios compared to MUFA/SFA ratios (Table 3). Likewise, the percentage of 18:2 (the predominant polyunsaturated

Table 2
Production treatment effects on lamb carcass traits

	Initial weight (kg)	Shorn final weight (kg)	Days to slaughter	Hot carcass weight (kg)	Dressing percentage	Backfat thickness (cm)	Body wall thickness (cm)	USDA yield grade
Treatment								
P	34.06 a	57.15 b	220 a	28.70 b	50.21 b	0.46 b	2.36 b	1.5 b
FL	34.47 a	56.61 b	134 b	30.93 a	54.64 a	0.86 a	3.63 a	2.6 a
RF	34.97 a	63.28 a	206 c	32.20 a	50.91 b	0.91 a	3.51 a	2.6 a
Breed type								
Merino cross	34.56 a	58.51 a	186 a	29.76 b	50.99 b	0.66 b	2.97 b	2.0 b
Rambouillet	34.43 a	59.56 a	188 a	31.49 a	52.89 a	0.81 a	3.38 a	2.5 a

a–c Means in the same column within the same data category (treatment or breed type) which are not followed by a common letter are different ($P < 0.05$).

Table 3
Fatty acid compositions (%) of diets for RF and FL lambs, supplement for P lambs, and pasture plants

Fatty acid	P supplement[a]	FL diet[b]	RF diet	Pasture plants					
				Broom weed	Klein grass	Purple + wrights threeawn	Silver bluestem	Sideoats grama	Tobosa grass
12:0	0.04	0.01	0.52	21.05	5.86	3.69	5.65	6.76	2.31
14:0	0.14	0.14	0.62	3.57	3.92	3.48	4.29	6.45	5.13
15:0	0.04	0.03	0.24	5.50	0.44	0.74	0.93	0	0.76
16:0	15.85	15.27	22.84	20.99	26.68	32.12	34.90	30.69	30.43
16:1	0.52	0.52	0.28	0	0.44	0.76	0.77	1.26	1.20
17:0	0.10	0.08	0.26	4.25	0.55	1.02	1.24	0	1.40
17:1	0.03	0.08	0.04	0.07	0	0	0	0	0
18:0	1.81	1.67	2.18	3.25	7.38	5.82	7.82	8.89	12.45
18:1	29.21	31.29	10.26	6.31	12.83	10.62	13.30	13.43	20.77
18:2	49.15	48.38	26.37	7.16	18.65	22.20	14.50	21.40	17.60
18:3	2.35	1.83	34.98	2.87	2.53	4.57	2.64	4.10	2.43
20:0	0.22	0.23	0.39	3.72	10.28	20.70	5.56	4.18	2.33
20:1	0.15	0	0	0	0.40	0	0	0	0
22:0	0.14	0.17	0.61	12.11	5.26	6.70	4.43	2.83	1.69
22:1	0.10	0.12	0.06	2.99	0	0	0	0	0
23:0	0.02	0.06	0.08	1.09	0.73	1.47	0	0	0
24:0	0.14	0.12	0.26	5.06	4.04	4.73	3.98	0	1.50
Total SFA	18.48	17.78	28.00	80.59	65.15	61.84	68.80	59.80	58.00
Total UFA	81.52	82.22	72.00	19.41	34.85	38.16	31.20	40.20	42.00
Total MUFA	30.02	32.01	10.64	9.38	13.67	11.39	14.06	14.70	21.97
Total PUFA	51.50	50.21	61.35	10.03	21.18	26.77	17.14	25.50	20.03
UFA/SFA	4.42	4.62	2.59	0.24	0.54	0.62	0.45	0.67	0.72
MUFA/SFA	1.63	1.80	0.38	0.12	0.21	0.18	0.20	0.25	0.38
PUFA/SFA	2.79	2.58	2.20	0.12	0.32	0.43	0.25	0.43	0.34

[a] Supplement No.2 in Table 1.
[b] Diet No.3 in Table 1.

acid) was higher than that of 18:1 (the predominant monounsaturated acid) in all samples other than tobosagrass.

Among the feeds/supplement, the RF-lamb feed had a higher SFA percentage than did the FL-lamb feed or the supplement given to P lambs, because the proportion of 16:0 (the predominant saturated fatty acid) was markedly higher in the RF-lamb feed. All the pasture plants, except broomweed, were higher in 16:0 percentage when compared to the FL- and RF-lamb feeds and P-lamb supplement. In broomweed, the percentage of 12:0 (a medium-chain saturated acid) was exceptionally high.

Fatty acid compositions of the pasture plants (Table 3), which P lambs were expected to have consumed during the production treatment, differed greatly from those of the pasture plants analyzed in our previous study on goats (Rhee, Waldron, Ziprin, & Rhee, 2000). Plant species in the previous study were different from those in the current study, except sideoats grama, although adjacent rangeland pastures were used (in different years). Lipid extracts from the pasture plants (including sideoats grama) analyzed in the goat study contained more UFA than SFA (vs. more SFA than UFA in the pasture plant extracts of the current study). For sideoats grama (the common plant species in the two studies), SFA levels were ~36% in the previous study and ~60% in this study, while total MUFA and PUFA levels were 19 and 45%, respectively, vs. 15 and 26%, respectively. Such differences between the two studies may be due partly to the pasture condition/rainfall during production treatment and the maturity stage of the plants. The rangeland was very dry throughout the current study. Nevertheless, lipid extract of each plant in the goat study had more SFA when compared to the extract of the grain ration (~19% SFA) used for feedlot treatment in the study (Rhee et al., 2000). Such was also the case in this lamb study, but with larger differences (Table 3).

Fatty acid profiles of the IM fat (total fat extracted from *semimembranosus* muscle) are shown in Table 4 by breed type. For Merino × Rambouillet lambs, the SFA content of the IM fat was greater with P and RF treatments than with FL treatment, with the reverse being the case for the UFA content. For Rambouillet lambs, RF treatment resulted in the highest SFA content. For both breed types, the MUFA content in IM fat was lower with P than with FL and RF, whereas the PUFA content was lower with RF than with P and FL.

Fatty acid profiles of the SC fat (total fat extracted from subcutaneous adipose tissue adjacent to *semimembranosus* muscle) are shown in Table 5. In the SC fat from Merino × Rambouillet lambs, the following differences due to

Table 4
Production treatment effects on fatty acid composition (%) of intramuscular fat

Fatty acid	Production treatment					
	P		FL		RF	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Merino cross lambs						
14:0	2.30 a	0.34	1.93 b	0.29	1.98 b	0.51
15:0	0.31 a	0.05	0.33 a	0.08	0.25 b	0.09
16:0	24.23 b	1.46	24.69 b	1.24	26.92 a	2.11
16:1	1.87 a	0.27	1.58 ab	0.46	1.44 b	0.75
17:0	1.16 b	0.09	1.56 a	0.33	1.16 b	0.18
18:0	16.64 a	1.27	12.70 b	1.22	15.75 a	1.81
18:1	44.15 b	2.53	48.21 a	2.13	47.63 a	3.53
18:2	6.31 a	1.54	6.57 a	1.48	2.93 b	0.58
18:3	0.45 b	0.48	0.30 b	0.08	1.33 a	0.37
20:4	2.57 a	0.70	2.13 b	0.57	0.73 c	0.25
Total SFA	44.64 a	2.17	41.21 b	2.24	46.06 a	3.05
Total UFA	55.36 b	2.17	58.79 a	2.24	53.94 b	3.05
Total MUFA	46.03 b	2.62	49.79 a	2.10	48.95 a	3.52
Total PUFA	9.33 a	2.15	9.00 a	1.99	4.98 b	1.00
UFA/SFA	1.25 b	0.11	1.43 a	0.13	1.18 b	0.14
MUFA/SFA	1.04 b	0.10	1.21 a	0.10	1.07 b	0.14
PUFA/SFA	0.21 a	0.05	0.22 a	0.05	0.11 b	0.02
Rambouillet lambs						
14:0	2.20 a	0.36	2.12 a	0.49	2.06 a	0.40
15:0	0.29 b	0.07	0.38 a	0.10	0.27 b	0.15
16:0	24.58 b	0.89	24.87 b	1.23	27.37 a	1.91
16:1	1.92 a	0.36	1.39 b	0.54	1.43 b	0.22
17:0	1.06 b	0.16	1.54 a	0.32	0.98 b	0.14
18:0	15.22 a	1.70	13.50 b	1.49	14.65 a	1.82
18:1	45.54 b	2.29	47.87 a	1.73	48.75 a	1.87
18:2	6.33 a	1.44	6.05 a	1.38	2.66 b	0.41
18:3	0.51 b	0.19	0.39 c	0.13	1.04 a	0.18
20:4	2.42 a	0.84	1.92 b	0.61	0.79 c	0.33
Total SFA	43.35 b	1.75	42.40 b	1.99	45.33 a	2.02
Total UFA	56.65 a	1.75	53.60 a	1.99	54.67 b	2.02
Total MUFA	47.39 b	2.23	49.25 a	1.74	50.18 a	1.94
Total PUFA	9.25 a	2.16	8.35 a	1.96	4.49 b	0.75
UFA/SFA	1.31 a	0.09	1.36 a	0.12	1.21 b	0.10
MUFA/SFA	1.10 b	0.08	1.17 a	0.08	1.11 b	0.09
PUFA/SFA	0.21 a	0.05	0.20 a	0.05	0.10 b	0.02

a–c Means within the row which are not followed by a common letter are different ($P < 0.05$).

treatments were observed: RF > FL in SFA content; P = FL > RF in MUFA content; and RF > P in PUFA content. In the SC fat from Rambouillet lambs, however, total SFA, MUFA and PUFA contents were not significantly different among the three production treatments.

The fatty acid saturation (or unsaturation) differences between the tissue fats from RF lambs and those from FL lambs (Tables 4 and 5) were not as large as the differences observed between their diets (Table 3). Percentage of the primary saturated acid, 16:0, was 50% (0.50 fold) higher in RF diet compared to FL diet. In the IM fat from Merino cross and Rambouillet lambs, 16:0 percentage was only 9–10% (0.09–0.10 fold) higher with RF than FL treatment. Similar differences of RF vs. FL were found in the SC fat (9–11% higher with RF). These results could be explained based on the thesis that synthesis of a saturated fatty acid in ruminants is inhibited when the fatty acid is supplied by diet (Chilliard, 1993). As such, the de novo synthesis of 16:0 might have been less in RF lambs than in FL lambs since the RF diet provided more exogenous 16:0 than the FL diet. On the other hand, the second major saturated acid in lamb tissues, i.e. 18:0, could have been produced by elongation of 16:0 as well as by ruminal hydrogenation of dietary 18-carbon unsaturated fatty acids (Chang, Lunt, & Smith, 1992; Ekeren, Smith, Lunt, & Smith, 1992). Since specific quantitative contributions of the pasture plants and high-concentrate supplement to the total diet that P lambs consumed were not measured, it is not feasible to extend the dietary 16:0 effect hypothesis to P lambs.

Table 5
Production treatment effects on fatty acid composition (%) of subcutaneous adipose tissue

Fatty acid	Production treatment					
	P		FL		RF	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Merino cross lambs						
14:0	3.35 a	0.50	3.58 a	0.63	3.66 a	0.64
15:0	0.61 b	0.08	0.78 a	0.12	0.63 b	0.13
16:0	24.19 c	1.47	26.98 b	1.81	29.43 a	2.80
16:1	1.59 a	0.30	1.56 a	0.63	1.42 a	0.60
17:0	1.77 c	0.21	2.63 a	0.35	2.02 b	0.19
18:0	24.57 a	3.31	18.55 c	2.32	21.88 b	4.57
18:1	41.03 a	3.54	42.65 a	4.23	37.23 b	6.13
18:2	2.64 ab	0.53	2.93 a	0.61	2.27 b	0.71
18:3	0.25 b	0.05	0.24 b	0.05	1.42 a	0.62
20:4	0.01 b	0.03	0.08 a	0.03	0.06 a	0.06
Total SFA	54.49 ab	3.57	52.53 b	4.29	57.61 a	7.03
Total UFA	45.51 ab	3.57	47.47 a	4.29	42.39 b	7.03
Total MUFA	42.62 a	3.68	44.22 a	4.19	38.64 b	6.50
Total PUFA	2.90 b	0.55	3.25 ab	0.63	3.75 a	1.29
UFA/SFA	0.84 ab	0.12	0.92 a	0.15	0.76 b	0.20
MUFA/SFA	0.79 a	0.12	0.85 a	0.15	0.69 b	0.18
PUFA/SFA	0.05 b	0.01	0.06 ab	0.01	0.07 a	0.03
Rambouillet lambs						
14:0	3.78 a	0.64	4.07 a	1.35	4.10 a	0.95
15:0	0.65 b	0.11	0.86 a	0.21	0.65 b	0.16
16:0	26.38 b	3.26	26.92 b	1.83	29.79 a	2.71
16:1	1.76 a	0.33	1.85 a	0.40	1.57 a	0.46
17:0	1.89 b	0.35	2.57 a	0.62	1.87 b	0.26
18:0	23.96 a	4.64	19.14 b	3.79	20.04 b	3.39
18:1	38.84 a	8.40	41.87 a	4.72	39.04 a	4.68
18:2	2.38 a	0.79	2.30 a	0.42	1.87 b	0.39
18:3	0.37 b	0.15	0.35 b	0.11	1.02 a	0.34
20:4	0.02 c	0.03	0.07 a	0.03	0.05 b	0.05
Total SFA	56.65 a	8.00	53.57 a	5.25	56.45 a	5.29
Total UFA	43.35 a	8.00	46.43 a	5.25	43.55 a	5.29
Total MUFA	40.59 a	8.27	43.72 a	4.91	40.62 a	4.83
Total PUFA	2.76 a	0.83	2.72 a	0.45	2.93 a	0.69
UFA/SFA	0.79 a	0.19	0.88 a	0.18	0.79 a	0.17
MUFA/SFA	0.74 a	0.19	0.83 a	0.17	0.73 a	0.15
PUFA/SFA	0.05 a	0.01	0.05 a	0.01	0.05 a	0.02

a–c Means within the row which are not followed by a common letter are different ($P < 0.05$).

The level of 18:1 (the predominant monounsaturated acid) as a percentage of total unsaturated fatty acids also differed markedly among lamb diets, but only to a minor degree among lamb tissue samples. When calculated from the data in Tables 4 and 5, 18:1 constituted 80–89% (mean = 85%) of total UFA in muscle samples from Merino cross and Rambouillet lambs, and 88–90% (mean = 90%) in adipose tissue. By comparison, 18:1 made up 28–49% (mean = 37%), 36, 38, and 14% of total UFA in pasture plants, P supplement, FL diet, and RF diet, respectively, as computed with the Table 3 data. Much of the 18:1 increase in lamb tissues (vs. diets) could have resulted from desaturation of 18:0 (whether supplied by diet or produced in situ from elongation of 16:0 and shorter-chain acids). One could hypothesize that the exogenous/dietary 18:1 could have inhibited the activity of the desaturase converting 18:0 to 18:1, thus maintaining a roughly constant level of 18:1, as a percentage of total UFA, in lamb tissues (particularly in adipose tissue).

When we evaluated fatty acid composition of goat diets (a grain ration for feedlot goats and grazing in rangeland, without any supplement, for pasture lambs) vs. intramuscular fat (Rhee et al., 2000), fatty acid profile differences between the fat from pasture goats and that from the grain-fed goats were also smaller than the differences between pasture plants and the grain diet.

When correlation coefficients were computed from mean values, fatty acid saturation (or unsaturation) of the muscle tissue (IM) fat correlated ($P < 0.05$) with that of the feeds including the P-lamb supplement ($r = 0.81$ for SFA, $r = -0.81$ for UFA). However, no

significant ($P > 0.05$) correlation was found between the adipose tissue (SC) fat and the feeds (r values of 0.68 and −0.68). Fatty acid saturation of the IM fat also correlated ($P < 0.05$) with final shorn weight ($r = 0.82$ for SFA, $r = -0.82$ for UFA), but not with other carcass traits. Fatty acid composition of the SC fat did not correlate with any of the carcass traits evaluated.

The percentage fatty acid composition data of our muscle tissue (*semimembranosus*) and subcutaneous adipose tissue samples (Tables 4 and 5) have been compared to the US Department of Agriculture Handbook 8-17 (USDA, 1989) lamb data on "separable" lean and "separable" fat. For this comparison, we used the percentage composition data (relative to total fatty acids) on the separable lean and fat (Rhee, 2000), which were calculated from the sample weight-based data (g fatty acid/100 g sample) in the USDA handbook. Total SFA, MUFA and PUFA percentages were not markedly different between our muscle samples (either Merino cross or Rambouillet lambs) and the USDA handbook's separable lean (41.96% SFA, 47.20% MUFA, 10.74% PUFA). On the other hand, our subcutaneous adipose samples were higher in SFA percentage (52.53–57.61% vs. 46.23%) and lower in PUFA percentage (2.72–3.75% vs. 8.35%) when compared to the separable fat. Note that the separable lean or fat in the USDA handbook represented a composite of lean or fat portions separated with knife from various retail cuts (with no breed and production method specified), and the separable fat included both subcutaneous fat and seam (intermuscular) fat.

4. Conclusions

RF lambs generally were similar to FL lambs in carcass traits (other than dressing percentage). Fatty acid profiles of P-lamb tissues were more related to that of the supplement than to those of the pasture plants, since a large proportion of the diet consumed by P lambs consisted of a high-concentrate supplement supplied to them. Although the muscle fat from RF lambs contained more saturated fatty acids than that of feedlot or pasture lambs, the differences were relatively small (although statistically significant) and would likely be of little practical significance relative to human nutrition. On the other hand, the PUFA content in muscle fat was much lower (more than 45%, or 0.45 fold, less) in RF than P and FL treatments. As a result, the lean meat from RF lambs potentially could be more stable toward oxidative quality deterioration than the FL and P lamb counterparts. This needs to be assessed in future research. Production treatment effects on tissue fatty acid profiles differed between the two lamb breeds, depending on tissue type (muscle or adipose tissue).

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