Estimation of Carcass Tissue Composition from Carcass Joint in Male Lambs

AKIF UYSAL[1]*, FILIZ AKDAĞ[1], MUSTAFA UĞURLU[1], DENIZ AY[1], BUKET NACAR[1], BÜLENT TEKE[1]

[1] Ondokuz Mayis University, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry, 55139, Samsun, Turkey.

SUMMARY

This study was carried out to estimate the tissue compositions of half-carcasses of male lambs by using carcass joints. The study's live material consisted of 45 male lambs from Akkaraman, Karayaka, and Herik breeds. After weaning, the male lambs were fed with lamb concentrate feed and alfalfa. They were then transferred to slaughter when they reached 40 kg live weight. The left half-carcasses of all lambs were divided into seven joints: neck, anterior rib, rib, loin, leg, flank, and foreleg, in order to determine the tissue composition of carcass joints and half-carcasses. All carcass joints were dissected into muscle, subcutaneous fat, intermuscular fat, bone tissue and other remaining tissues. The study found that the percentage of muscle was higher in the leg (61.33%), while the percentage of fat was higher in the flank (36.03%). The percentage of bone was similar in all joints except the flank. It was also found that the variation in adipose tissue was higher than the variation in other tissues in all carcass joints.High phenotypic correlation coefficients were determined between the tissue composition of carcass joints and half-carcass tissue composition. In addition, the regression coefficients determined for all carcass joints were statistically significant in the prediction of half-carcass tissue composition. The significant phenotypic correlation and regression coefficients indicate that the tissue composition of carcass joints and half-carcass are related. Although the regression coefficients calculated for the estimating of total muscle and bone weight in the half carcass were found to be statistically significant, the coefficients for joints other than the leg and foreleg were low. The regression coefficients for total fat were high except for the anterior rib. The study revealed that the tissues in the leg were more important in predicting the weight of muscle and bone in the half-carcass, and the adipose tissue in the loin was more determinant in predicting the weight of fat than the other joints. In addition, the results of this study indicate that utilizing only a single carcass joint is not effective in the estimating of carcass tissue composition.

KEY WORDS

Carcass dissection; Fat tissue; Lamb; Muscle weight; Regression.

INTRODUCTION

Sheep breeding is very important to the feeding and subsistence of the populace in arid regions with large meadows and pasture lands. Sheep are mostly raised for their milk in many Mediterranean and East European countries, but mainly for lamb meat production in Türkiye. Although there is a sufficient sheep population in Türkiye that can be used for lamb production, indigenous breeds with low meat yield and quality are generally used for meat production (1).

In recent years, people have tended to consume low-fat or lean meat (reason for healthy eating) to meet their nutritional needs because of socioeconomic developments (2). Consumer preference for lean or low-fat meat has led the meat production sector to focus on lean meat production in addition to increasing meat yield. The demands of consumers have made the determination of the amount of meat, bone and fat in carcasses that is, the estimation of carcass tissue composition, even more important (3,4). In addition, the rapid and reliable determination of carcass composition contributes to the recommendation of the correct feeding methods of animals in line with consumer demands, optimizing animal production and thereby increasing the economic gains of enterprises (5,6).

Carcass composition can be determined by using subjective (condition grading) or objective (ultrasound, magnetic resonance, video image analysis and computed tomography) methods. Due to the inadequate applicability and reproducibility (due to the cost of acquiring the necessary equipment and the need for trained specialists) of the equipment and methods used in objective methods in estimating carcass composition, their reliability has not been fully demonstrated (2,7). On the other hand, many previous studies have reported that physical separation of half-carcasses by dissection is the most effective method for estimating carcass tissue composition. However, this method has its disadvantages: It is very time-consuming and requires experienced workers and much labour (8,9,10). These disadvantages have led to the necessity to investigate alternative methods that require less labour and can be conducted

Corresponding Author:
Akif Uysal (akif.uysal@omu.edu.tr)

in a shorter time without dissecting the whole carcass (7,11,12). Hence, some studies have concluded that carcass composition can be estimated by dissecting certain carcass joints (5,9,12,). However, in previous studies, variation among breeds in growth rate and adipose tissue has led to different results in the estimation of carcass composition (2).

Akkaraman is an indigenous fat-tailed sheep breed that accounts for 45% of the country's sheep population (13). The Karayaka sheep is known for its long and thin tail, its small size and its tasty meat. The Herik sheep is a semi-fat-tailed breed obtained through irregular crossbreeding of Akkaraman and Karayaka (1). This study was carried out to estimate the half-carcass tissue compositions of Akkaraman, Karayaka, and Herik breed male lambs using carcass joints.

MATERIAL AND METHODS

Animals and Caring

The study was performed on the education and research farm within the university, situated at 41°N and 36°E, in Samsun Province, Türkiye, where the altitude is approximately 165 m. The live material of the study consisted of a total of 45 male lambs of Akkaraman (n=14), Karayaka (n=15) and Herik (n=16) breeds, which were weaned and fattened at the age of approximately 2.5 months. After weaning, the male lambs were fed with lamb concentrate feed (16.05% crude protein and 2844 kcal/kgME) and alfalfa (17.25% crude protein and 2031 kcal/kgME). They were transferred to slaughter when they reached an average live weight of 40 kg (40.14 ± 0.78 kg). After slaughter, the carcass characteristics of the lambs were determined.

Slaughtering and Carcass Traits

All the lambs were slaughtered after fasting for 16 h with ad libitum to water according to standard commercial procedures. Head, feet, skin, tail, testes and all internal organs (lung, heart, spleen, liver, gastrointestinal system, kidney, and omental fat) were removed from the lambs after slaughter, and the carcasses were kept at 4ºC for 24 hours. Each carcass was divided into two cuts (right and left) from the median line, and the weights of the half-carcasses were measured. The left half-carcasses were divided into seven joints: neck, anterior rib, rib, loin, leg, flank, and foreleg (14).

The weights of the carcass joints were determined, and each carcass joint was dissected using the method reported by Fisher and de Boer (15) to determine the tissue composition. Muscle, subcutaneous fat, intermuscular fat, bone tissue, and the remaining tissues (ligaments, tendons, major blood vessels and thick connective tissue associated with some muscles) were separated and weighed. The percentage of each carcass joint to half-carcass weight was calculated to determine the carcass joint percentage. Finally, the percentage of tissues to the weight of the related joint was used to determine the tissue composition percentage in the carcass joints.

Statistical Analysis

Descriptive statistics of carcass characteristics, the tissue composition of half-carcass and tissue composition of carcass joints of Akkaraman, Karayaka and Herik male lambs were analysed. Pearson correlation analysis was used to determine the relationship between the tissue composition of the half-carcass and carcass joints. A simple linear regression analysis was conducted to predict carcass tissue composition using joint tissue weights as independent variables. In regression analysis, regression coefficients (R^2) and residual standard deviations (RSD) were used to assess the accuracy of predictors. SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of carcass characteristics, carcass joint weights and the percentages of Akkaraman, Karayaka and Herik breed male lambs. The percentage of leg joints to half-carcass weight was higher than the percentage of other joints in the male lambs of all three breeds with similar pre-slaughter body weights. The percentages of leg joints to half-carcass weight was 36.6% in the Akkaraman, 33.83% in the Karayaka and 35.38% in the Herik breeds. These results are similar to the leg percentages reported in previous studies on the same breeds (16,17,18).

Table 2 presents the descriptive statistics of the tissue composition of the half-carcasses. The percentage of muscle in the half-carcasses was 59.03% in the Akkaraman, 55.37% in the Karayaka and 55.83% in the Herik male lambs. The total fat percentage in half-carcasses was 14.39%, 22.94%, and 21.16% for Akkaraman, Karayaka, and Herik lambs, respectively. In previous studies on Akkaraman lambs, Karabacak and Boztepe (16) reported the muscle percentage in half-carcass as 49.5%, while Mis and Öztürk (19) reported it as 71%. Oğan (20) determined the muscle percentage as 58.8% in Karayaka male lambs, while Teke et al. (21) determined it as 48.3% in Herik male lambs. Karabacak and Boztepe (16) determined the fat percentage in the carcass of Akkaraman male lambs at a similar value to the results of this study. Oğan (20) reported that the fat percentage in the carcass of Karayaka male lambs was lower than the result of this study, while Teke et al. (21) reported a higher percentage in Herik lambs. Previous studies reported different carcass tissue compositions in lambs of similar breed, age and sex. This may be due to the differences of climate factors and feed content of these animals. Ruiz-Ramoz et al. (22) reported that climatic and physiological conditions caused fluctuations in the feed intake of animals, and as a result of these fluctuations, changes in organ weights and carcass tissue composition occurred. They also reported that feed containing high levels of metabolisable energy caused a decrease in bone percentage and an increase in fat and muscle percentage in sheep carcasses.

Table 3 indicates the descriptive statistics of the tissue composition of carcass joints (muscle, bone and fat weight) in relation to carcass joint weights. A general evaluation of the tissue composition of the carcass joints revealed that the muscle percentage was higher in the leg part (61.33%), whereas the fat percentage was higher in the flank joint (36.03%). Bone percentages were similar across all parts except the flank. Mis and Öztürk (19) reported that the muscle percentage was close to each other in the foreleg, rib, loin and leg joints of Akkaraman breed male steers raised under intensive conditions and determined the muscle percentage in the leg as 67%. The same study reported that fat percentage was higher in the rib (20.8%), while bone percentage was higher in the foreleg (20.5%). Oğan (20) determined that the muscle percentage in the leg and foreleg joints of Karayaka male lambs was at hig-

Table 1 - Descriptive statistics of carcass traits and carcass joint weights and ratios in Akkaraman, Karaya and Herik male lambs.

Traits	Akkaraman (n=14)		Karayaka (n=15)		Herik (n=16)		Total (n=45)	
	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV
Pre-slaughter live weight, kg	40.30 ± 0.96	2.38	40.10 ± 0.82	2.05	40.14 ± 0.64	1.60	40.14 ± 0.78	1.95
Half-carcass weight, kg	7.62 ± 0.40	5.35	8.10 ± 0.23	2.85	7.87 ± 0.35	4.48	7.87 ± 0.38	4.86
Neck weight, kg	0.54 ± 0.04	9.06	0.64 ± 0.04	6.87	0.61 ± 0.08	14.29	0.60 ± 0.07	12.40
Anterior rib weight, kg	0.67 ± 0.12	19.08	0.80 ± 0.10	13.18	0.64 ± 0.11	17.86	0.71 ± 0.13	18.98
Rib weight, kg	0.65 ± 0.06	9.51	0.81 ± 0.06	8.05	0.76 ± 0.08	11.46	0.74 ± 0.09	13.18
Loin weight, kg	0.49 ± 0.05	11.50	0.64 ± 0.06	10.27	0.58 ± 0.07	12.53	0.57 ± 0.08	15.51
Leg weight, kg	2.79 ± 0.18	6.45	2.74 ± 0.20	7.32	2.78 ± 0.10	3.64	2.77 ± 0.16	5.86
Foreleg weight, kg	1.45 ± 0.10	7.40	1.43 ± 0.08	6.01	1.42 ± 0.07	5.11	1.43 ± 0.08	6.15
Flank weight, kg	0.95 ± 0.06	7.25	1.00 ± 0.11	11.54	1.06 ± 0.13	12.97	1.01 ± 0.11	11.74
Neck percentages, %	7.19 ± 0.56	7.87	8.00 ± 0.64	8.05	7.73 ± 0.87	11.37	7.65 ± 0.77	10.13
Anterior rib percentages, %	8.83 ± 1.60	18.15	9.98 ± 1.33	13.36	8.23 ± 1.35	16.44	9.00 ± 1.58	17.56
Rib percentages, %	8.56 ± 0.75	8.83	10.09 ± 0.88	8.76	9.68 ± 1.02	10.59	9.47 ± 1.08	11.18
Loin percentages, %	6.47 ± 0.70	10.89	7.95 ± 0.74	9.42	7.37 ± 0.87	11.85	7.28 ± 0.97	13.38
Leg percentages, %	36.66 ± 1.51	4.14	33.83 ± 2.26	6.68	35.38 ± 1.51	4.28	35.26 ± 2.10	5.96
Flank percentages, %	12.58 ± 0.07	6.29	12.42 ± 1.21	9.76	13.50 ± 1.46	10.85	12.85 ± 1.27	9.92
Foreleg percentages, %	19.11 ± 1.00	5.24	17.71 ± 0.83	4.68	18.07 ± 0.69	3.84	18.28 ± 1.01	5.54

Mean: Mean square value; SD: Standard deviation, CV: Coefficient of variation

Table 2 - Descriptive statistics of half-carcass tissue composition in Akkaraman, Karayaka and Herik male lambs.

Traits	Akkaraman (n=14)		Karayaka (n=15)		Herik (n=16)		Total (n=45)	
	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV
Total muscle weight, kg	4.50 ± 0.32	7.13	4.48 ± 0.24	5.43	4.39 ± 0.21	4.97	4.45 ± 0.26	5.85
Total bone weight, kg	1.68 ± 0.11	6,63	1.42 ± 0.09	6.89	1.48 ± 0.08	5.63	1.52 ± 0.14	9.46
Total fat weight, kg	1.09 ± 0.21	19,61	1.86 ± 0.30	16.55	1.66 ± 0.20	12.26	1.55 ± 0.40	25.95
Total other weight, kg	0.31 ± 0.06	20.76	0.32 ± 0.04	14.76	0.32 ± 0.04	13.35	0.32 ± 0.05	16.12
Total muscle percentages, %	59.03 ± 2.65	4.49	55.37 ± 3.02	5.45	55.83 ± 1.90	3.41	56.67 ± 2.97	5.24
Total bone percentages, %	22.07 ± 1.01	4.61	17.63 ± 1.21	6.89	18.86 ± 1.11	5.90	19.45 ± 2.15	11.06
Total fat percentages, %	14.39 ± 3,04	21,13	22.94 ± 3.54	15.44	21.16 ± 2.04	9.65	19.65 ± 4.63	23.58
Total other percentages, %	4.04 ± 0.66	16.35	4.05 ± 0.58	14.42	4.18 ± 0.51	12.28	4.10 ± 0.57	14.07

Mean: Mean square value; SD: Standard deviation, CV: Coefficient of variation

her values than the other joints and reported that the muscle percentage in both carcass parts was 67%. The same study also revealed that the fat percentage was higher in the loin and rib joints, while the bone percentage was higher in the rib joints. Teke et al. (23) divided the half-carcass of Herik breed male lambs into five joints: rib, loin, leg, foreleg and others and reported that the muscle percentage of the leg was 56% and the muscle percentage of the foreleg was 61%. The same study reported that the fat percentage was higher in the loin, while the bone percentage was higher in the foreleg.

An evaluation of the coefficients of variation of the tissues in the half-carcass in this study revealed that the of variation of adipose tissue (23.58%) was higher than that of other tissues. A similar situation was also valid for the coefficients of variation of the tissues in the carcass joints, and the variation of adipose tissue was higher than the variation of other tissues in all carcass parts (Table 2 and Table 3). Timon and Bichard (24) reported that the coefficient of variation of adipose tissue in half-carcasses and carcass parts of 25-week-old 80lb live-weight male lambs was higher than that of other tissues. Previous studies on lambs of different breeds reported that the variation of adipose tissue (subcutaneous and intermuscular adipose tissue) among carcass tissues is higher than other tissues [2,7,20, 25].

Table 4 shows Pearson's correlation coefficients between total muscle, bone and fat weights in half-carcass and muscle, bone and fat weights in carcass joints, while Table 5 presents simple linear regression for the estimation of tissue composition in half-carcass. High phenotypic correlation coefficients ($P< 0.01$) were found between the weights of muscle, bone and fat in the carcass joint and the weights of muscle, bone and fat in the half-carcass (anterior rib moderate) (Table 4). In addition, the phenotypic correlation coefficients of total carcass bone and muscle weight with muscle and bone weight in the leg and foreleg were higher than in the other joints. Similarly, the highest correlation was found between total carcass fat weight and loin fat weight. Demir (26) determined phenotypic correlati-

Table 3 - Mean value, standard deviation and coefficients of variation of tissue composition percentages of carcass joints.

Traits	Akkaraman (n=14)		Karayaka (n=15)		Herik (n=16)		Total (n=45)	
	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV
Neck								
Muscle	60.18±4.47	7.44	55.99±3.44	6.14	58.51±4.30	7.36	58.19±4.35	7.48
Bone	26.73±2.88	10.77	19.73±1.65	8.40	23.01±2.52	10.98	23.07±3.68	15.96
Fat	8.49±2.98	35.14	19.36±3.90	20.17	12.70±3.91	30.81	13.61±5.71	41.94
Anterior rib								
Muscle	57.98±3.29	5.67	54.89±3.61	6.58	57.09±3.95	6.92	56.64±3.79	6.69
Bone	24.52±3.57	14.59	20.27±2.23	11.02	21.77±3.49	16.02	22.13±3.54	16.01
Fat	8.74±3.40	38.96	17.83±3.82	21.46	12.40±4.25	34.30	13.07±5.30	40.56
Rib								
Muscle	54.88± 4.64	8.46	49.24±4.11	8.36	48.41±2.96	6.13	50.70±4.79	9.45
Bone	24.55±2.98	12.14	17.88±3.50	19.60	20.53±3.52	17.16	20.90±4.26	20.39
Fat	15.39±3.86	25.10	28.71±5.25	18.30	26.44±3.82	14.47	23.76±7.17	30.18
Loin								
Muscle	59.23±3.79	6.40	51.70±4.18	8.09	49.76±3.00	6.04	53.35±5.43	10.18
Bone	19.26±1.72	8.95	13.95±0.86	6.21	15.16±0.97	6.42	16.03±2.54	15.89
Fat	17.10±4.50	26.33	30.91±4.80	15.55	31.11±3.34	10.74	26.68±7.72	28.93
Leg								
Muscle	62.88±2.74	4.36	60.48±3.03	5.01	60.78±2.15	3.53	61.33±2.80	4.56
Bone	21.82±1.39	6.39	17.91±1.39	7.76	18.53±1.14	6.20	19.35±2.13	11.00
Fat	12.53±2.88	23.01	18.17±3.04	16.77	17.71±2.19	12.40	16.25±3.67	22.58
Flank								
Muscle	50.37±3.79	7.53	44.87±5.72	12.75	45.50±3.98	8.75	46.80±5.10	10.89
Bone	16.35±1.68	10.31	12.08±1.56	12.92	13.04±2.01	15.47	13.75±2.50	18.24
Fat	30.02±4.72	15.72	39.72±7.02	17.68	37.82±4.82	12.74	36.03±6.89	19.12
Foreleg								
Muscle	61.31±2.65	4.32	58.51±3.39	5.80	58.87±2.36	4.01	59.51±3.02	5.09
Bone	23.88±2.33	9.79	20.07±1.80	8.99	21.63±1.63	7.55	21.81±2.44	11.19
Fat	11.47±3.20	27.94	17.56±3.06	17.48	15.71±2.66	16.97	15.01±3.85	25.66

Mean: Mean square value; SD: Standard deviation, CV: Coefficient of variation

ons between the tissue composition of half-carcass and the tissue composition of carcass parts in curly lambs, similar to the results of this study. Dıaz et al. (27) reported positive correlations between carcass and carcass joint compositions, and the correlation coefficients of total muscle and bone weights in the carcass with muscle and bone weights of the leg, loin and foreleg joints were high. The same study revealed that the amount of fat in the carcass had high correlation coefficients with the adipose tissue in the loin, leg, foreleg and flank, respectively. Gastelum-Delgado et al. (28) found a high positive correlation between carcass tissue composition and tissue composition of the foreleg in Blackbelly male lambs.

An analysis of the regression coefficients for the estimation of half-carcass tissue composition (Table 5) indicated that the amount of muscle in the leg could explain 59% of the variation in total muscle amount. A similar situation was also valid for total bone content, and bone content in the leg alone could explain 78% of the variation in total bone content. Although the regression coefficients of other carcass joints for both traits (total muscle and bone weight) were statistically significant, the coefficients (R^2) were low values between 0.11 and 0.35. The R^2 values of the carcass parts related to the estimation of the total fat amount in the half-carcass were the highest for the adipose tissue in the loin (R^2 = 0.83). Therefore, loin adipose tissue is considered to be more determinant than all other joints in the estimation of total adipose tissue (Table 5). Carrasco et al. (29) determined the regression coefficients for the muscle, bone and fat amounts of the leg joint as R^2 = 0.84, R^2 = 0.68 and R^2 = 0.77, respectively, and stated that the leg part was more determinant in the estimation of carcass tissue composition than the other parts. However, the same study reported the highest regression coefficient for the amount of fat in the carcass for the adipose tissue in the loin (R^2= 0.87). Miguelez et al. (30) reported that the regression coefficients for leg and loin muscle tissue were higher than those for other joints when estimated carcass muscle weight. In the same study, they reported that the regression coefficients of fat and bone tissues at the waist were higher than those obtained for other parts when estimating the fat to bone ratio in the carcass. Dıaz et al. (27) stated that the tissue composition of leg and loin parts can be utilised in the estimation of carcass composition. Furthermore, Keçici et al. (2) reported that no carcass part alone is sufficient for the estimation of carcass tissue composition, and the carcass characteristics and carcass measurements should be utilised to estimate the tissue composition of half-carcass at a percentage of 65% and above. Finally, Gastelum-Delgado et al. (28)

Table 4 - Phenotypic correlation coefficients between tissue composition of carcass joints and tissue composition in half-carcass.

Carcass joint tissue[a]	Half-carcass tissue		
	Total muscle weight	Total bone weight	Total fat weight
Neck	0.444**	0.463**	0.804**
Anterior rib	0.521**	0.354*	0.703**
Rib	0.498**	0.546**	0.862**
Loin	0.327*	0.484**	0.910**
Leg	0.767**	0.881**	0.803**
Flank	0.516**	0.621**	0.865**
Foreleg weight	0.698**	0.809**	0.798**

[a] Related tissue in the carcass; *P< 0.05; **P< 0.01

Table 5 - Simple linear regression equations for the prediction of half-carcass tissue composition in male lambs.

Dependent variable	Independent variables	R^2	RSD	P	Equations
Total muscle weight (kg)					
	Neck muscle (NM)	0.20	0.233	**	Y= 3.524 + 2.668*NM
	Anterior rib muscle (ARM)	0.27	0.222	***	Y= 3.699 + 1.898*ARM
	Rib muscle (RM)	0.25	0.226	***	Y= 3.308 + 3.061*RM
	Loin muscle (LM)	0.11	0.246	*	Y= 3.848 + 2.007*LM
	Leg muscle (LeM)	0.59	0.167	***	Y= 1.578 + 1.694*LeM
	Flank muscle (FM)	0.27	0.223	***	Y= 3.280 + 2501*FM
	Foreleg muscle (FoM)	0.49	0.186	***	Y= 2.343 + 2.471*FoM
Total bone weight (kg)					
	Neck bone (NB)	0.21	0.128	***	Y= 0.986 + 3.938 * NB
	Anterior rib bone (ARB)	0.12	0.135	*	Y= 1.308 + 1.398 *ARB
	Rib bone (RB)	0.30	0.121	***	Y= 1.106 + 2.731*RB
	Loin bone (LB)	0.23	0.126	***	Y= 0.947 + 6.398*LB
	Leg bone (LeB)	0.78	0.068	***	Y= 0.505 + 1.905*LeB
	Flank bone (FB)	0.39	0.113	***	Y= 1.047 + 3.467*FB
	Foreleg bone (FoB)	0.65	0.085	***	Y= 0.460 + 3.410*FoB
Total fat weight (kg)					
	Neck fat (NF)	0.65	0.239	***	Y= 0.888 + 7.859*NF
	Anterior rib fat (ARF)	0.49	0.289	***	Y= 0.999 + 5.795*ARF
	Rib fat (RF)	0.74	0.204	***	Y= 0.671 + 4.842*RF
	Loin fat (LF)	0.83	0.167	***	Y= 0.624 + 5.911*LF
	Leg fat (LeF)	0.65	0.240	***	Y= 0.161 + 3.090*LeF
	Flank fat (FF)	0.75	0.202	***	Y= 0.217 + 3.637*FF
	Foreleg fat (FoF)	0.64	0.243	***	Y= 0.370 + 5.485*FoF

*P< 0.05; **P< 0.01; ***P< 0.001; R^2 : Regression coefficients; RSD: Residual standard deviations

indicated that it would be more beneficial to utilise the tissue composition of the foreleg joint in the estimation of carcass composition.

CONCLUSION

In conclusion, this study determined that leg muscle and bone tissues were more determinative in the estimation of the amount of muscle and bone in the half-carcass, and the loin fat tissue was more determinative in the estimation of the amount of fat in the carcass than the other joints. In addition, it was concluded that the use of a single carcass joint to estimate the tissue composition of the half-carcass could not be effective. New studies on different breeds and more lambs would be useful to provide suggestions for estimating carcass composition from a single carcass for field use.

Ethical Approval

This study was approved by the Ondokuz Mayis University Animal Experiments Local Ethics Committee (Approval no: HADYEK 2019/54).

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Authors' Contributions

Akif Uysal and Filiz Akdağ designed this study. Field work: Akif Uysal, Mustafa Uğurlu, Deniz Ay, Buket Nacar. Data collect: Akif Uysal, Filiz Akdağ, Mustafa Uğurlu, Deniz Ay, Buket Nacar and Bülent Teke. Statistical analyze: Filiz Akdağ and Akif Uysal. Writing manuscript: Akif Uysal. Critical revisions: Filiz Akdağ, Bülent Teke, Mustafa Uğurlu, Deniz Ay, Buket Nacar.

Conflict of interest

The authors declare no conflict of interest.

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