Selcuk J Agr Food Sci, (2018) 32 (3), 530-534

e-ISSN: 2458-8377 DOI: 10.15316/SJAFS.2018.133

Selcuk Journal of Agriculture and Food Sciences

Determination of Breed and Carcass Regions by Discriminant Analysis Considering the Fatty Acid Compositions in Lambs

Ali KARABACAK[1,*], İsmail KESKIN[1]

[1]Selcuk University, Faculty of Agriculture, Department of Animal Science, Konya, Turkey

ARTICLE INFO

Article history:

Received date: 07.12.2018
Accepted date: 12.12.2018

Keywords:

Fatty acids
Carcass regions
Discriminant analysis
sheep

ABSRACT

The aim of this study was to determine the breed and carcass regions according to fatty acids in lambs by using discriminant analysis. In the study, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), trans fatty acid, conjugated linoleic acid (CLA), omega 3 (ω 3), omega 6 (ω 6), palmitic acid (C16: 0), margaric acid (C17: 0), stearic acid (C18: 0) and oleic acid (C18: 1 ω9) of 47 male lambs belonging to 5 different sheep breeds (Akkaraman, Dağlıç, Kıvırcık, Malya and Karacabey Merino) were used. With the discriminant analysis method, whether sheep breeds and carcass region (leg, shoulder, rib, and breast) could be classified correctly or not was investigated.

At the end of the study, it was determined that when fatty acids were used, sheep breeds could be classified correctly in 57.3% and carcass regions in 70.2%. According to the results obtained, it was seen that the fatty acids resolved according to both sheep breeds and carcass regions. In this way, it can be said that by looking at the fatty acids content of the meat sample taken from any place, clues can be obtained about which sheep breed or which carcass region it might belong to.

1. Introduction

Discriminant analysis, whose main objective is to determine in which class the intended units to be classified, is a multivariate analysis method used widely in applied science in recent years.

The discriminant functions obtained through discriminant analysis consist of linear components of the estimation variables. Discriminant functions reveal which predictive variables affect the difference between groups. These variables that affect the difference between groups are called discriminant variables. Another function of discriminant analysis is to identify the group of the unit that belongs to any of the groups but which group it belongs to is unknown with the minimum error. Discriminant analysis can be performed to identify discriminant functions and to determine the differential variables that affect the intergroup discrimination most by means of these functions and to determine in which group the unit, whose group is unknown, is to be included (Ünsal, 2000).

Kocabaş et al. (2003) stated in their study using the physical properties of the wool in discriminant analysis that it could be performed accurately in the classification of the wool whose origin is unknown in Akkaraman or Anatolian Merino breeds.

İlhan et al. (2009), stated at the end of the study on Akkaraman and Awassi sheep that wool characteristics could be classified according to breeds and which breed the wool, whose origin is unknown, belongs to could be determined with the help of discriminant analysis.

Karacaoğlu (2004) performed discriminant analysis to discriminate Anatolian Bee Aegean Ecotype and Italian bee x Aegean ecotype hybrid bee using the morphological features of bees. In the research, it has been shown that appropriate results in the discrimination of bee breeds will be obtained by discriminant analysis. Karacaoğlu & Fıratlı (1998) carried out discriminant analysis using morphological features for the discrimination of some Anatolian honey bee ecotypes and hybrids, Güler et al. (1999) for important honey bee breeds and ecotypes in Turkey, Gençer & Fıratlı (1999) used the discriminant analysis in the separation of Central Anatolia ecotypes and the Caucasian breed by using the morphological features of honey bees and showed that accurate decisions could be obtained as a result.

In this study, it was investigated whether sheep breeds and carcass zones (leg, shoulder, rib, breast) could be classified correctly or not with discriminant

*Corresponding author e-mail: *akarabacak@selcuk.edu.tr*

analysis method using the saturated fatty acids (SFA, MUFA, PUFA, TRANS, CLA, ω 3, ω 6, C16: 0, C17: 0, C18: 0 and C18:1 and ω9) of 47 male lambs belonging to 5 different sheep breeds (Akkaraman, Dağlıç, Kıvırcık, Malya and Karacabey Merino).

2. Materials and Methods

The animal material of the study consisted of 47 lambs belonging to 5 different breeds (Akkaraman (9), Dağlıç (10), Kıvırcık (10), Malya (10), and Karacabey Merino (8)). Lambs at the age of weaning and at average 20 kg live weight were fed up for 68 days at the Prof. Dr. Orhan Düzgüneş Research and Application Farm of the Department of Animal Science, Faculty of Agriculture and during the fattening period, lambs were given as concentric fodder *ad libitum* and 150 grams of dry alfalfa grass daily. At the end of the fattening lambs were slaughtered and fatty acids were determined.

The data obtained from each feature were analyzed using SPSS (18.0) statistical program. In discriminant analysis, it is aimed to differentiate between the groups by means of a discrimination function that maximizes the difference. Therefore a separation function must be determined. The general formula of this function is as follow;

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + ... + b_p X_p$$

In this function b_i shows the coefficient of linear components.

Discriminant analysis is divided into two groups as linear and quadratic discriminant analysis. The main aim of linear and quadratic discriminant analysis is to divide the observations into two or more groups according to the determined functions and to ensure that new observations are optimally assigned to these groups. In linear discriminant analysis, covariance matrices of all groups are assumed to be similar. This assumption is not used in quadratic discriminant analysis (Özdamar, 2004). The homogeneity of covariance matrices of the groups is tested by Box's M test. Since the covariance matrices of the groups used in this study were not homogeneous, quadratic discriminant analysis was applied.

3. Results and Discussion

Average and standard deviations of fatty acids (SFA, MUFA, PUFA, TRANS, CLA, ω3, ω6, C16:0, C17:0, C18:0 and C18:1 ω9) in the sheep of Akkaraman, Dağlıç, Kıvırcık, Malya and Karacabey Merino can be seen in Table 1.

Table 1
Mean and standard deviations of fatty acids in different sheep breeds

Fatty Acids	Sheep Breeds				
	Akkaraman (n=40)	Dağlıç (n=39)	Kıvırcık (n=39)	Malya (n=30)	Konya Merino (n=30)
SFA	42.94 ± 3.47^{AB}	41.24 ± 3.92^{B}	41.88 ± 3.24^{AB}	44.20 ± 3.26^{A}	44.23 ± 3.27^{A}
MUFA	45.06 ± 4.35^{A}	45.19 ± 5.97^{A}	44.89 ± 5.03^{A}	39.89 ± 4.90^{B}	39.80 ± 4.90^{B}
PUFA	4.15 ± 0.95^{B}	4.43 ± 1.16^{B}	4.44 ± 1.40^{B}	5.81 ± 1.32^{A}	5.84 ± 1.32^{A}
TRANS	6.28 ± 1.60^{B}	8.06 ± 2.70^{A}	7.48 ± 2.43^{AB}	8.84 ± 2.11^{A}	8.85 ± 2.11^{A}
CLA	1.58 ± 0.28^{A}	1.08 ± 0.35^{B}	1.32 ± 0.39^{B}	1.28 ± 0.30^{B}	1.26 ± 0.30^{B}
ω3	0.60 ± 0.19^{A}	0.42 ± 0.11^{B}	0.57 ± 0.29^{AB}	0.73 ± 0.30^{A}	0.74 ± 0.31^{A}
ω6	3.55 ± 0.82^{B}	4.01 ± 1.07^{B}	3.87 ± 1.22^{B}	5.11 ± 1.15^{A}	5.10 ± 1.16^{A}
C16:0	23.07 ± 2.08^{A}	21.55 ± 1.94^{B}	23.15 ± 1.89^{A}	23.84 ± 1.72^{A}	23.84 ± 1.72^{A}
C17:0	3.65 ± 0.92^{A}	3.35 ± 0.91^{A}	3.47 ± 0.90^{A}	2.60 ± 0.73^{B}	2.59 ± 0.73^{B}
C18:0	9.64 ± 2.26^{B}	11.07 ± 2.74^{AB}	9.42 ± 2.12^{B}	12.37 ± 3.56^{A}	12.37 ± 3.56^{A}
C18:1 ω9	35.97 ± 3.45^{AB}	37.20 ± 4.71^{A}	36.17 ± 3.91^{AB}	33.46 ± 3.80^{B}	33.37 ± 3.81^{B}

A, B: Superscript letters within the same row indicate significance (P< 0.01), n= breeds (regardless of regions)

As can be seen in Table 1, the highest value for SFA was in Konya Merino and the lowest value was in Dağlıç. MUFA has the highest value in Akkaraman, Dağlıç, Kıvırcık breed while PUFA has the highest value in Malya and Konya Merino. The lowest TRANS and the highest CLA were obtained in Akkaraman sheep.

$$L_1 = 0.89SFA + 2.56MUFA - 1.38PUFA + 2.22TRANS + 0.52\omega3 + 2.90\omega6 + 1.58C{:}16 + 0.34C{:}17 + 1.60C{:}18 + 2.43C18{:}1\ \omega9$$

$$L_2 = 7.83SFA + 10.29MUFA - 6.65PUFA + 5.06TRANS - 1.24\omega3 - 3.87\omega6 - 1.08C{:}16 - 1.17C{:}17 - 0.74C{:}18 + 0.36C18{:}1\ \omega9$$

$$L_3 = -2.57SFA + 0.79MUFA - 4.87PUFA + 0.91TRANS + 1.33\omega3 + 4.08\omega6 + 2.61C{:}16 + 1.15C{:}17 + 1.61C{:}18 + 0.31C18{:}1\ \omega9$$

$$L_4 = 0.46SFA - 0.57MUFA - 24.04PUFA + 0.81TRANS + 4.65\omega3 + 21.18\omega6 - 0.42C{:}16 - 1.14C{:}17 - 0.68C{:}18 + 0.37C18{:}1\ \omega9$$

When linear separation functions are examined, MUFA, TRANS, ω6 and C18:1 ω9 were more effective on L1; SFA, MUFA, PUFA and TRANS on L2; SFA, PUFA and ω6, and C16 on L3, and PUFA, ω3 and ω6 were on L4.

Table 2
Distribution of breeds by groups

Sheep Breeds	Actual Group				
	Akkaraman	**Dağlıç**	**Kıvırcık**	**Malya**	**Konya Merino**
	N (%)	N (%)	N (%)	N (%)	N (%)
Akkaraman	31(77.5%)	0 (0.0%)	7 (17.5%)	0 (0.0%)	2 (5.0%)
Dağlıç	4 (10.3%)	27 (69.2%)	5 (12.8%)	0 (0.0%)	3 (7.7%)
Kıvırcık	8 (20.5%)	10 (25.6%)	16 (41.0%)	2 (5.1%)	3 (7.7%)
Malya	0 (0.0%)	3 (10.0%)	1 (3.3%)	11 (36.7%)	15 (50.0%)
Konya Merino	0 (0.0%)	4 (13.3%)	1 (3.3%)	8 (26.7%)	17 (56.7%)

As shown in Table 2, the correct classification rates for fatty acids in Akkaraman, Dağlıç, Kıvırcık, Malya and Konya Merino sheep were determined as 77.5%, 69.2%, 41.0%, 36.7% and 56.7%, respectively. While 31 of 42 Akkaraman sheep were in the actual group, 4 of them were in Dağlıç and 8 of them were in Kıvırcık group, but there was no Akkaraman sheep in Malya and Konya Merino group. The correct classification rate is higher in pure breeds.

When the first and second functions obtained from the canonical discrimination functions were used, the distribution of the breeds was as in Figure 1.

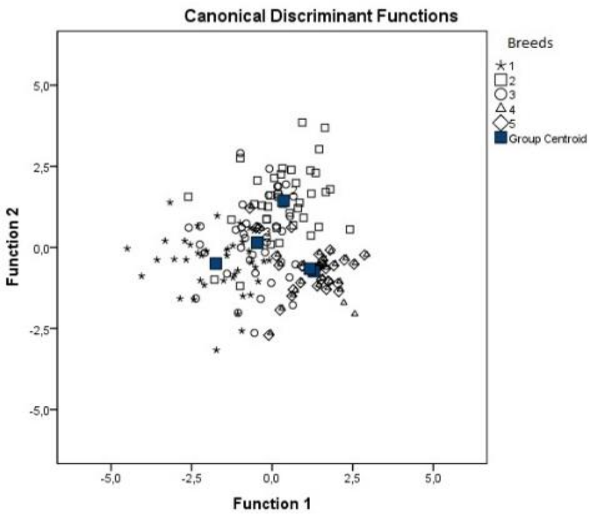

Figure 1
Canonical Discriminant Functions for Breeds

As can be seen from Figure 1, the Akkaraman and Dağlıç breeds were more clearly separated from other breeds.

The mean and standard deviations of fatty acids (SFA, MUFA, PUFA, TRANS, CLA, ω3, ω6, C16:0, C17:0, C18:0, and C18:1 ω9) compared to carcass regions (but without arms) are given in Table 3.

While there was no statistically significant difference between the leg, arm and rib regions of the carcass in terms of SFA fatty acid, chest part was different from these regions (P<0.01). MUFA has the highest value in the chest area while PUFA has the highest value in the leg area. The lowest TRANS were obtained from the chest region. In terms of CLA fatty acid, no statistically significant difference was found between the leg, arms, ribs and chest zones of the carcass.

The standardized linear canonical separation functions obtained for the classification of carcass regions are found as follows.

$$L_1 = -3.45SFA - 0.13MUFA - 0.57PUFA - 0.71TRANS - 0.02\omega3 + 0.68\omega6 + 2.64C{:}16 + 1.83C{:}17 + 2.76C{:}18 - 1.02\mathrm{C18{:}1\ \omega9}$$

$$L_2 = -2.60SFA + 3.67MUFA - 0.56PUFA + 0.08TRANS + 0.17\omega3 + 1.05\omega6 + 2.80C{:}16 + 0.94C{:}17 + 2.80C{:}18 - 1.79\mathrm{C18{:}1\ \omega9}$$

$$L_3 = 0.48SFA + 2.17MUFA + 19.44PUFA - 0.40TRANS - 3.48\omega3 - 16.23\omega6 - 0.48C{:}16 - 0.06C{:}17 + 0.34C{:}18 - 1.49\mathrm{C18{:}1\ \omega9}$$

Table 3
Mean and standard deviations of fatty acids by carcass regions

Fatty Acids	Carcass Parts			
	Leg (n=46)	Shoulder (n=45)	Rib (n=43)	Breast (n=44)
SFA	44.51±2.68^{A}	44.26±3.42^{A}	42.52±3.20^{A}	39.62±2.94^{B}
MUFA	39.51±3.24^{C}	41.22±4.47^{BC}	44.04±4.62^{B}	48.64±5.15^{A}
PUFA	5.63±1.31^{A}	4.84±1.44^{AB}	4.66±1.33^{B}	4.19±1.17^{B}
TRANS	9.03±2.03^{A}	8.44±2.15^{AB}	7.48±2.45^{BC}	6.16±2.01^{C}
CLA	1.33±0.31^{NS}	1.25±0.42^{NS}	1.27±0.36^{NS}	1.40±0.36^{NS}
ω3	0.70±0.30^{A}	0.54±0.24^{AB}	0.53±0.20^{B}	0.61±0.30^{AB}
ω6	4.92±1.12^{A}	4.32±1.29^{AB}	4.13±1.23^{B}	3.57±0.97^{B}
C16:0	23.29±1.76^{NS}	23.37±2.08^{NS}	22.87±2.48^{NS}	22.50±1.75^{NS}
C17:0	3.10±0.72^{B}	3.42±0.84^{AB}	3.86±0.99^{A}	2.39±0.58^{C}
C18:0	12.24±2.67^{A}	11.96±3.07^{A}	10.47±3.16^{A}	8.53±1.74^{B}
C18:1 ω9	32.74±2.61^{C}	33.93±3.30^{BC}	35.45±3.21^{B}	39.74±3.91^{A}

^{NS}: Not significant, $^{A, B, C}$: Superscript letters within the same row indicate significance (P <0.01), n= regions (regardless of breeds)

When the linear discrimination functions are examined, SFA, C: 16, C: 17, C1: 18 and C18:1 ω9 were more effective on L1, SFA, MUFA, ω6, C:16, C:18 and C18:1 ω9; on L2, MUFA, PUFA, ω3, ω6 and C18:1 ω9 were more effective on L3.

Table 4
Distribution of Carcass Regions into Groups

Carcass Parts	Actual Group			
	Leg	Shoulder	Rib	Breast
	N (%)	N (%)	N (%)	N (%)
Leg	30 (65.2%)	12 (26.1%)	1 (2.2%)	3 (6.5%)
Shoulder	10 (22.2%)	22 (48.9%)	11 (24.4%)	2 (4.4%)
Rib	2 (4.7%)	6 (14.0%)	35 (81.4%)	0 (0.0%)
Breast	5 (11.4%)	1 (2.3%)	0 (0.0%)	38 (86.4%)

As can be seen from Table 4, the correct classification rates for the fatty acids of the carcasses, leg, shoulder, rib and breast parts ignoring their breeds were determined as 65.2%, 48.9%, 81.4% and 86.4%, respectively. It is seen that the correct classification rate is higher in the leg, rib and breast areas of the carcass.

The distribution of the carcass regions was as in Figure 2 when the first and second functions obtained from the canonical discriminant functions were used.

As can be seen from Figure 2, while the regions of the carcass 1 (leg), 3 (rib) and 4 (breast) are more clearly distinguished, the shoulder region is also located between these three regions.

It was established that Akkaraman and Dağlıç breeds could be discriminated in Akkaraman, Dağlıç, Kıvırcık, Malya and Karacabey Merino sheep by using SFA, MUFA, PUFA, TRANS, CLA, ω3, ω6, C16:0, C17:0, C18:0 and C18:1 ω9 fatty acids, however, this rate was lower in the other breeds (Kıvırcık, Malya and Karacabey Merino).

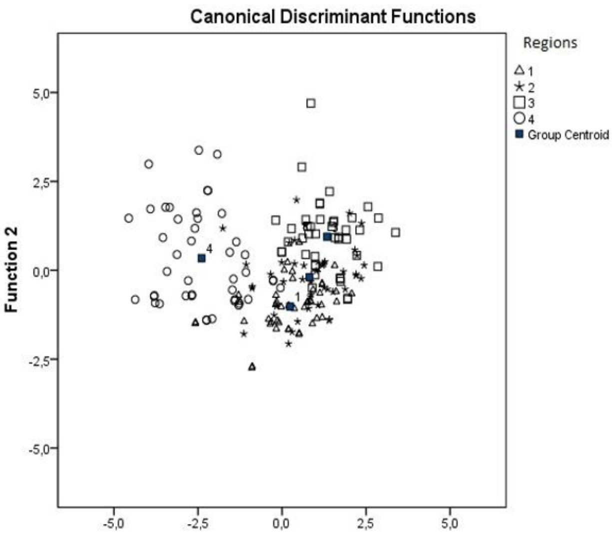

Figure 2.
Canonical Discriminant Functions for Regions

It was determined that 1 (leg), 3 (rib) and 4 (breast) zones could be discriminated more clearly by using SFA, MUFA, PUFA, TRANS, CLA, ω3, ω6, C16:0, C17:0, C18:0, and C18:1 ω9 fatty acids in the carcass regions, discrimination rate in the shoulder area was found lower.

As a result, when classification is made by discriminant analysis using SFA, MUFA, PUFA, TRANS, CLA, ω3, ω6, C16:0, C17:0, C18:0 and C18:1 ω9 fatty acids, it can be said that it is possible to distinguish the unknown meat and which breed it belongs to and from which part of the carcass it has been obtained.

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