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Evaluation of Major Cattle Breeds in Turkey for Slaughter and Carcass Traits Using MANOVA and Multidimensional Scaling Technique*

Sedat HAMDİ KIZIL[1], Muhterem AYDOĞAN [2]

[1] *Lalahan Livestock Central Research Institute, Lalahan- Ankara -TURKEY*
[2] *Ankara University, Faculty of Veterinary Medicine, Zootechny Department Ankara-TURKEY*

Summary : In this study, MANOVA and Multidimensional Scaling techniques were used for 11 slaughter traits (body weight, skin weight, head weight, leg weight, lung weight, heart weight, liver weight, spleen weight, testis weight, penis weight, internal fat weight) and 18 carcass traits (hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight, hot kidney weight, hot kidney fat weight, cold kidney weight, cold kidney fat weight, sirloin weight, rib-eye weight, short loin weight, round weight, bone weight, rib-eye area, fat thickness, hot dressing percentage, cold dressing percentage, bone ratio) to compare Turkish native cattle breeds (Native Black, East Anatolian Red, Southeast Anatolian Red), crossbreed (Native Black × Brown Swiss) and foreign breeds (Simmental, Holstein, Brown Swiss) in Turkey. Results of the two methods were similar and supported each other. Differences between foreign breeds (Simmental, Holstein and Brown Swiss) and native breeds and crossbreed (Native Black, East Anatolian Red, Southeast Anatolian Red, Native Black × Brown Swiss) were highly significant in favor of the foreign breeds. Simmental had the highest values in all traits except for testes weight and bone ratio. Holstein and Brown Swiss had similar values in all other traits except for skin weight, rib-eye weight and bone ratio. Native Black × Brown Swiss crossbreed had the highest and Native Black cattle had the lowest values among the three native breeds and crossbreed for all the 28 traits investigated, except for bone ratio. East Anatolian Red and Southeast Anatolian Red had similar values for all the traits investigated. Only for back fat thickness, native breeds and crossbreeds were similar to each other.

Key Words: Crossbreeding, MANOVA, multidimensional scaling, native breeds, slaughter and carcass traits

Türkiye'deki Başlıca Sığır Irklarının Kesim ve Karkas Özelliklerinin MANOVA ve Çok Boyutlu Ölçüm Tekniği Kullanılarak Değerlendirilmesi

Özet : Bu çalışmada, Türkiye'deki yerli ırklar (Yerli Kara, Doğu Anadolu Kırmızısı, Güneydoğu Anadolu Kırmızısı), melez (Yerli Kara × Esmer) ve kültür ırklarına (Simmental, Siyah Alaca, Esmer) ait, 11 kesim özelliği (canlı ağırlık, deri, baş, ayak, akciğer, kalp, karaciğer, dalak, testis, penis, iç yağı ağırlıkları) ve 18 karkas özelliğinin (sıcak karkas, soğuk karkas, sağ ön kol, sağ but, sıcak böbrek, sıcak böbrek yağı, soğuk böbrek, soğuk böbrek yağı, bonfile, pirzola, kontrfile, but etleri ve kemik ağırlıkları, MLD alanı (cm^2), kabuk yağı kalınlığı (cm), sıcak karkas yüzdesi, soğuk karkas yüzdesi, kemik oranı) karşılaştırılmasında MANOVA ve çok boyutlu ölçüm teknikleri uygulanmıştır. Her iki metodun sonuçları birbirine benzer ve birbirini destekler mahiyettedir. Kültür ırkları (Simmental, Siyah Alaca, Esmer) ile yerli ırklar (Yerli Kara, Doğu Anadolu Kırmızısı, Güneydoğu Anadolu Kırmızısı) ve melezler (Yerli Kara × Esmer) arasındaki farklar, kültür ırkları yönünde yüksek oranda önemli bulunmuştur. Simmental ırkı, testis ağırlığı ve kemik oranı haricindeki tüm özelliklerde en yüksek değerlere sahiptir. Siyah Alaca ve Esmer ırkları, deri ağırlığı, pirzola ağırlığı ve kemik oranı haricindeki tüm özelliklerde birbirine benzer değerlere sahiptir. Melezler, yerli ırklarla karşılaştırıldığında, kemik oranı haricindeki tüm özelliklerde en yüksek değerleri göstermiştir. Yerli Kara ırkında, yerli ırklar arasında kemik oranı haricindeki tüm özelliklerde en düşük değerler elde edilmiştir. Doğu Anadolu Kırmızısı ve Güneydoğu Anadolu Kırmızısı ise, incelenmiş olan tüm özellikler yönünden benzer değerlere sahip bulunmuştur. Sadece kabuk yağı kalınlığı yönünden, yerli ırk ve melezler birbirine benzerlik göstermiştir.

Anahtar Kelimeler: Çok boyutlu ölçüm, kesim ve karkas özellikleri, MANOVA, melezleme, yerli ırklar

Introduction

In this study, only a limited number of traits that reported before in other studies have been investigated and univariate methods were used to analyze the values (1, 2, 5, 8, 9, 13, 15, 16, 17, 19). Univariate methods does not account for correlations among the traits, which leads to lost information. The pre-determined Type I error rate (α) cannot be maintained. Pala et al. (18) reported that when only weaning weight was evaluated, Angus crosses had the lowest values (lightest calves) among three breeds (Angus × Hereford, Brangus × Hereford and Gelbvieh × Hereford) having added conception rate to the equation, Angus crosses had the highest values. This indicates that evaluating a single trait may lead to inaccurate conclusions when other traits may be of economic value too. All traits are considered as essential when there are correlations among them. Multivariate Analysis of Variance (MANOVA) and Multidimensional Scaling techniques are used to analyze the data to obtain detailed information on the breeds. Univariate statistics such as ANOVA are usually employed when the effects of independent factors on dependent factors are investigated. If there are no correlations among the traits investigated, univariate statistics may be valid (23), while this is not

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*This study was prepared from the doctorate thesis of author the case in most situations. When a limited number of traits investigated are dependent of each other, univariate statistics leads to lost information and the pre-determined Type I error rate (α) cannot be maintained due to ignored correlations (21).

Multidimensional Scaling technique (MDS) is a technique for finding a configuration of points in low dimensional space that represents multivariate data. Basically, the purpose of MDS is to provide a visual representation of the pattern of proximities (i.e., similarities or distances) among a set of objects. The MDS plots the objects on a map such that objects that are very similar to each other are placed close to each other on the map, and objects that are very different from each other are placed far away from each other on the map. That is, the points that are close to each other in the map indicate a relationship between the pairs as well as similarity of behavior with respect to the remaining variables or objects.

This study was conducted to compare the slaughter and carcass traits of common Turkish native cattle breeds (Native Black cattle, East Anatolian Red, Southeast Anatolian Red), crossbreed (Native Black × Brown Swiss) and foreign breeds (Simmental, Holstein, Brown Swiss) in Turkey.

Materials and Methods

Data used in this study were obtained from 49 Native Black Cattle, 32 East Anatolian Red, 14 Southeast Anatolian Red cattle, 51 Native Black × Brown Swiss crosses, 44 Simmental, 57 Holstein Friesian and 76 Brown Swiss male cattle. The cattle were slaughtered at The General Directorate of Meat and Fish Slaughterhouse in Malatya, Turkey.

Ages of the cattle were determined by means of post-mortem inspection of incisive teeth. The cattle were grouped according to their ages. While the age of the first group of cattle was younger than two-year-old, the second group was older than two-year-old.

The animals were weighed with scale (Egemal Quantum brand) sensitive to 1 kg. After slaughter, head and legs (below carpal and tarsal, skin (including the head), lungs, heart, liver and internal fat were weighed using Minipond 85 x DA floor scale with electronic reader and FUJITSU DL 3400 printer. The scale was 200 g sensitive. The slaughter traits were body weight, skin weight, head weight, legs weight, lungs weight, heart weight, liver weight, spleen weight, testes weight, penis weight and internal fat weight.

Carcass was divided into two parts vertically and the hot carcass was weighed using ESIT FIXUM IQA air scale with electronic reader and FUJITSU DL-3600 printer. The scale was 200 g sensitive. Kidneys and kidney fat were removed immediately after weighing the hot carcass, and were weighed using DIGI SM 15 electronic scale. The scale was sensitive to 1 g. The same scale was used to measure rested (cold) weights of the kidneys and kidney fat after the organs were rested for 24 hours in 4°C. The right and left parts of the carcass were cleaved between the 12th and 13th ribs to divide the carcass into front (chest and ribs) and back (hind legs) parts. Next, they were rested for 24 hours at 4°C and were weighed. The following was performed: (i) rib eye area and the outer fat of the front part were drawn on a tracing paper, (ii) Musculus longissimus dorsi (MLD) section was measured using planimeter, (iii) fat thickness was measured using a ruler.

Right side of the cold carcass was dissected to weigh the sirloin, rib-eye area, short loin, round cuts and the bones. The values were multiplied by two to obtain the values for the whole body. Dissection of the carcass was performed according to the rules of the Turkish Standards Institution (6). The carcass traits were hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight, hot kidney weight, hot kidney fat weight, cold kidney weight, cold kidney fat weight, sirloin weight, rib-eye weight, short loin weight, round weight, bone weight, rib-eye area, fat thickness, hot dressing percentage, cold dressing percentage, and bone ratio.

MANOVA and Multidimensional Scaling (MDS) techniques were used in all analyses. MANOVA techniques were employed to investigate the differences among 7 breeds, using PROC GLM procedure of SAS (20). The values were corrected for age of the cattle and season effects. In MANOVA , the null hypothesis (H_0) and the alternative hypothesis (H_1) can be stated as follows:

$$H_0 : \mu_{11} = \mu_{12} = ... = \mu_{17}, ... \text{and} \mu_{291} = \mu_{292} = ... = \mu_{297}$$

H_0 states that means of the variable 1 are the same for all 7 breeds and means of the 29 variables are the same for all 7 breeds. μ_{ij} refers to the population mean of variable i in breed j (i=1, 2,... , 29; j=1, 2,…,7).

H_1: The 7 breeds do not have the same means for variable (trait) 1, …, and the same means for variable 29.

Bonferroni confidence intervals were used to investigate the differences of the breeds with the following equation (1):

$$\overline{X}_{mi} - \overline{X}_{li} \pm t_{\left(n-k;\ \frac{\alpha}{pk(k-1)}\right)} \sqrt{\frac{w_{ii}}{n-k}\left(\frac{1}{n_m} - \frac{1}{n_l}\right)}$$

Where

i: dependent variable (i[th] traits)

m and l: breeds to be compared for the specified trait

w_{ii}: diagonal element of i[th] trait in error sum of squares matrix

p: number of traits

$$\delta_{ij} = a + bd_{ij} + e \quad (2)$$

k: number of breeds

According to distances, configuration distances were computed using the following linear regression equation:

Where

a: constant

b: regression coefficient or slope

d_{ij}: the distances between the points

e: residual

The degree of correspondence between the distances among points implied by MDS map and the matrix input by the user was measured (inversely) by a stress function. The smaller the stress, the better the representation (10, 14). Kruskal (14) suggests that stress should be informally interpreted according to the following guidelines. Stress coefficients for goodness of fit obtained in this study were given in Table1. The general form of these functions was as follows:

$$\text{Stress} = \sqrt{\frac{\sum\sum (f(X_{ij}) - d_{ij})^2}{\text{scale}}} \quad (3)$$

Where

d_{ij}: the Euclidean distance, across all dimensions, between points i and j on the map

$f(x_{ij})$: function of the input data, and scale refers to a constant scaling factor, used to keep stress values between 0 and 1. When the MDS map perfectly reproduces the input data

$f(x_{ij})$ - d_{ij}: for all i and j

Generally, classical MDS employs Euclidean distance to model dissimilarity. That is, the distance dij between points i and j is defined as:

$$d_{ij} = \sqrt{\sum (x_{ia} - x_{ja})^2}$$

Where

X_i: the position (coordinate) of point i (10, 14).

Table 1. Stress coefficients for goodness of fit

Stress	Goodness of fit
≤ 0.20	Poor
0.10-<0.20	Fair
0.05-<0.10	Good
0.025-<0.05	Excellent
0.00-<0.025	Perfect

Results

Least squares means, results of Bonferroni multiple comparisons, and stimulus (traits) coordinates were given in Table 2, 3 and 4, respectively. The F-statistics and Pillai's Trace statistics had the value of 10.23 and 3.039, respectively. Hence, it may be concluded that the seven breeds do not have the same means for all variable (trait) (P<0.01).

Table 2. Least squares means ($\overline{X}$) and their standard errors ($S_{\overline{X}}$)

Slaughter traits	TBC (n=49) ($\overline{X} \pm S_{\overline{X}}$)	CROSS (n=51) ($\overline{X} \pm S_{\overline{X}}$)	SAR (n=14) ($\overline{X} \pm S_{\overline{X}}$)	EAR (n=32) ($\overline{X} \pm S_{\overline{X}}$)	SIM (n=44) ($\overline{X} \pm S_{\overline{X}}$)	HOS (n=57) ($\overline{X} \pm S_{\overline{X}}$)	BSW (n=76) ($\overline{X} \pm S_{\overline{X}}$)
Body weight (kg)	218.87±11.52	358.72±12.44	293.30±15.05	288.33±21.34	580.05±11.97	497.03±12.23	476.32±10.03
Skin weight (kg)	23.16±1.17	37.24±1.26	26.11±1.52	29.51±2.19	54.43±1.21	48.42±1.23	48.42±1.24
Head weight (kg)	6.85±0.36	11.97±0.38	9.19±0.46	9.85±0.67	16.88±0.38	16.14±0.31	11.97±0.38
Legs weight (kg)	3.14±0.19	5.47±0.20	3.85±0.25	3.69±0.36	8.83±0.20	6.92±0.20	7.56±0.17
Lungs weight (kg)	2.59±0.12	4.03±0.13	3.37±0.15	3.22±0.22	5.51±0.12	5.37±0.12	5.17±0.10
Heart weight (kg)	0.77±0.10	1.24±0.10	1.14±0.13	0.86±0.18	3.51±0.10	1.94±0.10	1.62±0.08
Liver weight (kg)	2.78±0.13	4.39±0.14	3.71±0.17	3.75±0.25	6.10±0.14	5.71±0.14	5.53±0.11
Spleen weight (kg)	0.39±0.02	0.68±0.02	0.54±0.03	0.52±0.04	1.07±0.02	0.93±0.02	1.00±0.02
Testis weight (kg)	0.26±0.02	0.46±0.02	0.37±0.02	0.37±0.04	0.71±0.02	0.69±0.02	0.75±0.02
Penis weight (kg)	0.40±0.02	0.68±0.03	0.54±0.03	0.53±0.05	1.09±0.03	1.00±0.02	0.68±0.03
Internal fat weight (kg)	3.12±0.24	4.52±0.26	4.57±0.317	3.39±0.46	7.43±0.25	6.58±0.26	6.47±0.21
Carcass traits							
Hot carcass weight (kg)	129.27±7.38	223.14±8.00	177.36±9.64	175.71±13.86	365.22±7.67	313.13±7.83	297.84±6.42
Cold carcass weight (kg)	121.71±7.12	213.03±7.70	168.71±9.30	166.89±13.37	349.17±7.40	298.94±7.56	285.78±6.20
Right forequarter weight (kg)	34.39±2.04	60.05±2.20	47.73±2.66	47.01±3.82	98.17±2.11	86.16±2.16	79.95±1.77
Right hindquarter weight (kg)	26.52±1.54	46.71±1.66	36.62±2.01	36.84±2.89	76.40±1.60	63.28±1.63	62.97±1.34
Hot kidney weight (kg)	0.39±0.02	0.63±0.02	0.52±0.03	0.45±0.05	1.00±0.02	0.84±0.02	0.82±0.02
Hot kidney fat weight (kg)	3.18±0.37	5.65±0.40	4.58±0.48	4.35±0.69	11.21±0.38	8.88±0.39	7.63±0.32
Cold kidney weight (kg)	0.39±0.02	0.62±0.02	0.51±0.03	0.44±0.04	1.00±0.02	0.82±0.02	0.80±0.02
Cold kidney fat weight (kg)	3.13±0.37	5.59±0.40	4.52±0.48	4.29±0.69	11.07±0.38	8.78±0.39	7.55±0.32
Sirloin weight (kg)	1.46±0.10	2.71±0.11	2.20±0.13	1.99±0.18	4.47±0.10	3.70±0.10	3.73±0.09
Rib-eye weight (kg)	5.26±0.32	9.22±0.35	7.08±0.35	6.96±0.61	13.82±0.34	10.90±0.34	12.14±0.28
Short loin weight (kg)	2.84±0.18	5.12±0.20	3.78±0.24	3.47±0.35	9.14±0.19	6.90±0.20	7.03±0.16
Round weight (kg)	16.66±1.25	31.78±1.35	22.91±1.64	23.98±2.35	55.00±1.30	45.37±1.33	45.67±1.09
Bone weight (kg)	15.36±1.04	29.78±1.12	23.11±1.36	23.65±1.95	48.13±1.08	41.31±1.10	41.22±0.90
Rib-eye area (cm^2)	43.59±2.07	68.14±2.24	54.66±2.71	59.64±3.89	98.30±2.15	84.26±2.20	83.45±1.80
Fat thickness (cm)	0.33±0.02	0.39±0.01	0.37±0.01	0.38±0.01	0.51±0.02	0.48±0.02	0.52±0.02
Hot dressing percentage (%)	0.59±0.001	0.62±0.001	0.61±0.001	0.61±0.001	0.63±0.001	0.63±0.001	0.62±0.001
Cold dressing percentage (%)	0.55±0.001	0.59±0.001	0.58±0.001	0.58±0.001	0.60±0.001	0.60±0.001	0.59±0.001
Bone ratio (%)	0.13±0.001	0.14±0.001	0.13±0.001	0.15±0.001	0.14±0.001	0.14±0.001	0.15±0.001

TBC: Native Black Cattle, **CROSS:** Native Black × Brown Swiss crosses, **EAR:** East Anatolian Red,
SAR: Southeast Anatolian Red, **SIM:** Simmental, **HOS:** Holstein, **BSW**: Brown Swiss

Among native breeds and the crosses, Native Black × Brown Swiss crosses had the highest and Native Black cattle had the lowest values for all the 28 traits investigated, except for bone ratio (Table 2). The only similarity among the three breeds and the crosses was the fat thickness (Table 3). East Anatolian Red and Southeast Anatolian Red breeds had similar values for all traits (P> 0.05). Differences between Native Black × Brown Swiss crosses and Native Black were significant for all other traits measured except for the fat thickness (P<0.01). Differences between Southeast Anatolian Red and Native Black were also significant for all traits (P<0.05), except for skin weight, legs weight, heart weight, hot kidney fat weight, cold kidney fat weight, fat thickness and bone ratio. Native Black cattle and East Anatolian Red breeds had similar values for all 11 slaughter traits (P>0.05) except for head and liver weight (P<0.05). The two breeds were significantly different for the carcass traits hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight, bone weight, rib-eye area, hot dressing percentage, cold dressing percentage and bone ratio (P<0.01) while the differences were non-significant for hot kidney weight, hot kidney fat weight, cold kidney weight, cold kidney fat weight, sirloin weight, rib-eye weight, short loin weight, round weight and fat thickness (P>0.05). Rank of the animals for body weight was consistent with literature values (3, 4, 7, 11, 16, 22). The rib-eye areas in this study were higher than those reported in the studies by Alpan et al. (4), Arpacık et al. (7) and Çolpan (11) for East Anatolian Red. The rib-eye and round cut weights were lower and short loin weights were higher than those reported in the studies by Eker et al. (12) for East Anatolian Red breed. Simmental had the highest values in all traits except testes weight and bone ratio (Table 2). Holstein and Brown Swiss had similar values in all traits (P>0.05) except for skin weight, rib-eye weight and bone ratio. Simmental and Holstein cattle had similar values for head weight, lungs weight, liver weight, testes weight, penis weight, internal fat weight, fat thickness, hot dressing percentage, cold dressing percentage and bone ratio (P>0.05) while all other traits were different in (P<0.01). The relationship between these two breeds also exists between Simmental and Brown Swiss (Table 3). Results of this study supported results of Pala et al. (18).

In the MDS technique, the traits were placed on a map as objects (Figure 1, Figure 2). Derived stimulus configuration Euclidean distance model for native, crossbreds and foreign breeds, scatter plot of fit Euclidean distance model for foreign breeds were given in Figure 1, Figure3 and Figure 4 respectively. The four breeds (native breeds and crossbred) were far away on the map for body weight, skin weight, hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight, round weight, bone weight and rib-eye area. The breeds were close to each other for head weight, legs weight, lungs weight, heart weight, liver weight, spleen weight, testes weight, penis weight, internal fat weight, hot kidney weight, hot kidney fat weight, cold kidney weight, cold kidney fat weight, sirloin weight, rib-eye weight, short loin weight, fat thickness, hot dressing percentage cold dressing percentage and bone ratio. Among the 29 traits measured; legs weight, lungs weight, heart weight, liver weight, spleen weight, testes weight, penis weight, internal fat weight, hot kidney weight, cold kidney weight, cold kidney fat weight, sirloin weight, short loin weight, fat thickness, and hot dressing percentage were close to each other for foreign breeds (Simmental, Holstein and Brown Swiss). On the other hand, body weight, skin weight, head weight, hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight and rib-eye area were far away on the map for these breeds. Body weight, hot carcass weight, cold carcass weight, right forequarter weight, right hindquarter weight and rib-eye area seem to be the major traits determining the breed differences, and body weight differences seem to be the highest among the breeds (Figure 2, Table 4). Using MDS technique in comparing the breeds in addition to MANOVA increases the accuracy of results (20).

Discussion and Conclusion

The two statistical methods, MANOVA and Multidimensional Scaling had similar results in comparing the native and foreign breeds and their crosses for the 29 traits. This indicates that the results obtained from the two methods are reliable for the data examined. Southeast Anatolian Red or East Anatolian Red can be used for further crossbreeding studies. Rank of the animals for bone ratio was consistent with literature (7). One breed can replace another one for the traits considered here and Native Black should be used only in harsh conditions or when any of these breeds is not available. Simmental should be used as opposed to Holstein or Brown Swiss in Turkey's conditions for meat traits. Rank of the animals for body weight was consistent with literature (5). Holstein and Brown Swiss were similar for the traits investigated and they can replace each other.

In Figure 1 and 2, X1 to X29 and Y1 to Y29 represents traits for the Native Black cattle, East Anatolian Red, Southeast Anatolian Red and Native Black × Brown Swiss breeds. Y1 to Y29 represents the same traits for Simmental, Holstein Friesian and Brown Swiss.

As a result these two statistical methods were found to be equivalent to asses those kind of dataset used in this study.

Figure 1. Derived stimulus configuration Euclidean distance model for native and crossbreds

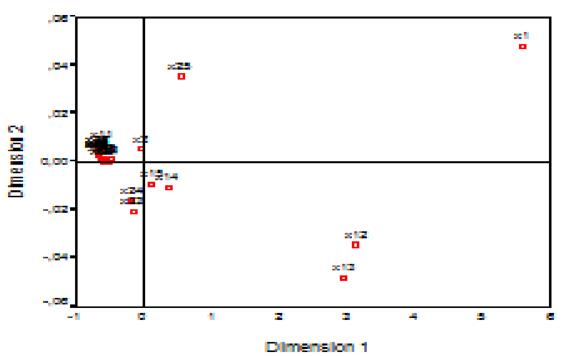
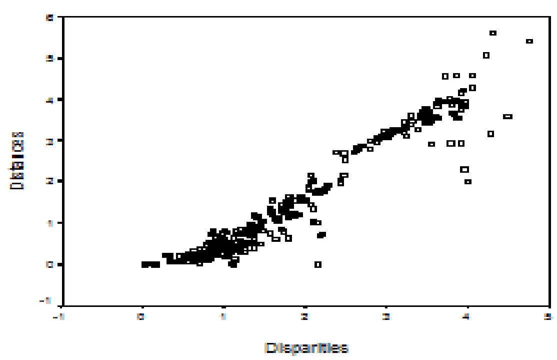


Figure 2. Scatter plot of fit Euclidean distance model for native and crossbreds



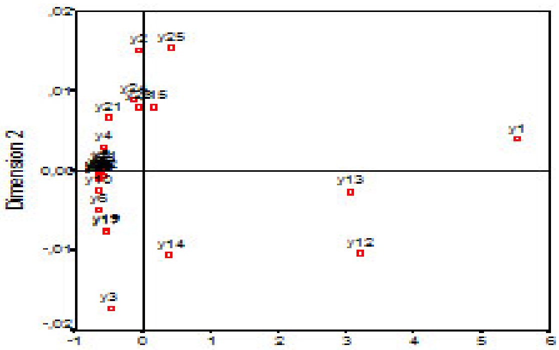


Figure 3. Derived stimulus configuration Euclidean distance model for foreign breeds

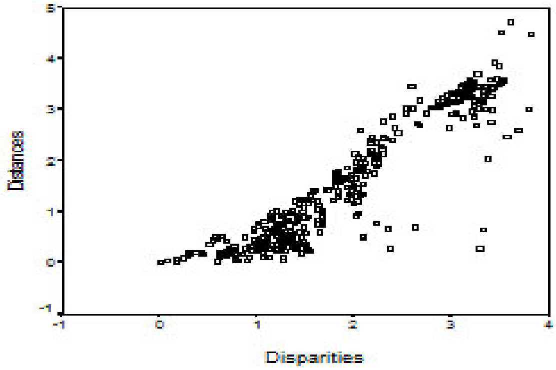


Figure 4. Scatter plot of fit Euclidean distance model for foreign breeds

Table 3. Results of Bonferroni multiple comparison test

Traits	TBC-CROSS	TBC-SAR	TBC-EAR	CROSS-SAR	CROSS-EAR	SAR-EAR	SIM-HOS	SIM-BSW	HOS-BSW
Slaughter traits									
Body weight (kg)	**	**	NS	**	**	NS	**	**	NS
Skin weight (kg)	**	NS	NS	**	**	NS	**	**	**
Head weight (kg)	**	**	**	**	NS	NS	NS	NS	NS
Legs weight (kg)	**	NS	NS	**	**	NS	**	**	NS
Lungs weight (kg)	**	**	NS	**	**	NS	NS	NS	NS
Heart weight (kg)	**	NS	NS	NS	NS	NS	**	**	NS
Liver weight (kg)	**	**	**	**	NS	NS	NS	**	NS
Spleen weight (kg)	**	**	NS	**	**	NS	**	ns	NS
Testis weight (kg)	**	**	NS	NS	NS	NS	NS	NS	NS
Penis weight (kg)	**	**	NS	**	**	NS	NS	NS	NS
Internal fat weight (kg)	**	**	NS	NS	NS	NS	NS	NS	NS
Carcass traits									
Hot carcass weight (kg)	**	**	**	**	**	NS	**	**	NS
Cold carcass weight (kg)	**	**	**	**	**	NS	**	**	NS
Right forequarter weight (kg)	**	**	**	**	**	NS	**	**	NS
Right hindquarter weight (kg)	**	**	**	**	**	NS	**	**	NS
Hot kidney weight (kg)	**	**	NS	NS	**	NS	**	**	NS
Hot kidney fat weight (kg)	**	NS	NS	NS	NS	NS	**	**	NS
Cold kidney weight (kg)	**	**	NS	**	**	NS	**	**	NS
Cold kidney fat weight (kg)	**	NS	NS	NS	NS	NS	**	**	NS
Sirloin weight (kg)	**	**	NS	**	**	NS	**	**	NS
Rib-eye weight (kg)	**	**	NS	**	**	NS	**	**	**
Short loin weight (kg)	**	**	NS	**	**	NS	**	**	NS
Round weight (kg)	**	**	NS	**	**	NS	**	**	NS
Bone weight (kg)	**	**	**	**	NS	NS	**	**	NS
Rib-eye area (cm^2)	**	**	**	**	NS	NS	**	**	NS
Fat thickness (cm)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Hot dressing percentage (%)	**	**	**	**	NS	NS	NS	NS	NS
Cold dressing percentage (%)	**	**	**	NS	NS	NS	NS	NS	NS
Bone ratio (%)	**	NS	**	NS	NS	NS	NS	**	**

**** :** ($P<0.01$) Statistically significant difference, **NS :** ($P>0.05$) Non significant

TBC: Native Black Cattle, **CROSS:** Native Black × Brown Swiss crosses, **EAR:** East Anatolian Red, **SAR:** Southeast Anatolian Red, **SIM:** Simmental, **HOS:** Holstein, **BSW**: Brown Swiss

Table 4. Stimulus (traits) coordinates

	Native Breeds		Foreign Breeds	
	Dim 1	Dim 2	Dim 1	Dim 2
Slaughter traits				
Body weight	**5.5837**	0.0476	**5.5106**	0.0039
Skin weight	-0.0463	0.0050	-0.0720	0.0151
Head weight	-0.4673	0.0007	-0.4930	-0.0172
Legs weight	-0.5847	-0.0001	-0.5797	0.0029
Lungs weight	-0.6012	0.0044	-0.6089	0.0006
Heart weight	-0.6507	0.0030	-0.6437	-0.0048
Liver weight	-0.5936	0.0048	-0.6037	0.0004
Spleen weight	-0.6608	0.0027	-0.6605	-0.0004
Testis weight	-0.6644	0.0027	-0.6640	-0.0004
Penis weight	-0.6607	0.0028	-0.6614	-0.0025
Internal fat weight	-0.5887	0.0067	-0.5911	0.0004
Carcass traits				
Hot carcass weight	**3.1464**	-0.0347	**3.2138**	-0.0104
Cold carcass weight	**2.9590**	-0.0484	**3.0451**	-0.0027
Right forequarter weight	0.3524	-0.0109	0.3793	-0.0106
Right hindquarter weight	0.1226	-0.0095	0.1345	0.0080
Hot kidney weight	-0.6616	0.0029	-0.6619	-0.0010
Hot kidney fat weight	-0.5760	0.0011	-0.5614	-0.0077
Cold kidney weight	-0.6617	0.0029	-0.6620	-0.0011
Cold kidney fat weight	-0.5772	0.0010	-0.5627	-0.0075
Sirloin weight	-0.6269	0.0013	-0.6251	-0.0003
Rib-eye weight	-0.5177	-0.0002	-0.5258	0.0066
Short loin weight	-0.5896	-0.0004	-0.5803	-0.0007
Round weight	-0.1531	-0.0206	-0.0910	0.0080
Bone weight	-0.1720	-0.0167	-0.1530	0.0089
Rib-eye area	0.5437	0.0355	0.3854	0.0154
Fat thickness	-0.6645	0.0038	-0.6665	-0.0006
Hot dressing percentage	-0.6595	0.0049	-0.6650	-0.0008
Cold dressing percentage	-0.6602	0.0047	-0.6654	-0.0008
Bone ratio	-0.6694	0.0033	-0.6707	-0.0009

Dim : Dimension

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Yazışma Adresi: Dr. Sedat Hamdi KIZIL
Hayvancılık Merkez Araştırma Enstitüsü Müdürlüğü
06852 Lalahan-Mamak/ANKARA
Tel: 0 312 8651196/194
Cep: 05336651332
Faks: 0 312 8651112
E- mail: sedathkizil@hotmail.com