INVESTIGATION OF MILK YIELD FROM CULTURE, CROSS-BRED AND NATIVE CATTLE BREEDS IN TURKEY BY MULTIVARIATE ANALYSIS OF VARIANCE (MANOVA)

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Abstract. In this study, milk yield from culture, cross-bred, and native cattle breeds in 7 geographical regions of Turkey were investigated by multivariate analysis of variance (MANOVA) in 2015. The values of Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root statistics used for the MANOVA test were 0.522, 0.546, 0.711 and 0.490, respectively. The corresponding F values for these statistics were found to be 2.422, 2.518, 2.594 and 5.634, respectively. Mean annual milk yield of cross-bred, culture, and native cattle breeds reached to be 3776.355, 2692.803 and 1311.513 kg, respectively. Therefore, the results of these statistics are very close to each other. As a result of the MANOVA test, the difference within milk yield between the regions was not significant for culture and native cattle breeds, whereas a significant difference was found in hybrid breed cattle ($P < 0.001$). As a result of the Bonferroni test, it was found that the milk yield difference in hybrid cattle was due to the difference in yield between Eastern Anatolia-Aegean, Eastern Anatolia-Marmara, Southeast Anatolia-Aegean and Southeast Anatolia-Marmara regions.
Keywords: *Wilks' Lambda, outlier, race, milk yield, geographical region*

Introduction

Production of animal products and per capita consumption of animal products are among the indicators of the development level of a country (Şapdeniz, 1993). Milk is one of the most important animal products. It is an essential nutrient for a sufficient and balanced human diet and for fulfilling the protein need of the ever-growing world population. Milk consumption is significant in the diets of people of all ages. Although milk has a key role in human diet and per capita consumption of milk has been on the rise in Turkey in recent years, it has not reached to a desired level yet (Akman, 2017).

Turkey has a great potential for increasing animal production due to its geographical position and land structure favorable for animal breeding. While Turkey ranks among the leading countries in terms of animal numbers, the yield per animal is not at a desired level. Therefore, researches performed in Turkey aim to improve the yield obtained per animal rather than to increase the number of animals (Yaylak, 2003). In the republican period, culture breeding cattle were imported from abroad for the improvement of the indigenous breeds. Cattle import activities, which started in the republican period, have continued until today. Currently, 88% of the cattle population consists of culture breeds and cross breeds. While the number of indigenous breeds has continuously reduced in the whole cattle population, the number of cross breeds has shown a significant increase. In researches performed to improve the milk yield obtained from cattle in Turkey, culture cattle breeding has been prioritized since 1958 (Kumlu and Akman, 1999).

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In researches on dairy cattle breeding in Turkey, the improvements in milk production, the effects of environmental and genotypic factors and the rate of these factors were emphasized (Alpan and Arpacık, 1998). Milk yield in cattle is affected by two factors, which are; the genotype of the animal and favorable environmental conditions (Tuncel, 1994). Breeding methods and selection are used to improve the milk yield capacity in terms of genetics. On the other hand, environmental factors can lead to long-term and daily changes.

Age, breed, live weight, lactation method, number of daily milking, feeding, ambient temperature, calving season, duration of dry period, diseases and exercises are among the factors that affect milk yield in cows.

In Turkey and in other countries, various researches have been performed on 305-day milk yield of the Holstein Friesian cattle (*Table 1*).

Table 1. *305-day milk yield of the Holstein Friesian cattle in Turkey and in other countries*

Year and authors	Country	Average milk yield	Number of animals
Türkyılmaz (2005)	Turkey	6491	544
Sattar et al. (2005)	Turkey	2772	499
Tekerli and Gündoğan (2005)	Turkey	6404	525
Bakır et al. (2009)	Turkey	6810	1302
Şahin and Ulutaş (2010)	Turkey	6976	536
Keskin and Boztepe (2011)	Turkey	5997	105
Duru et al. (2012)	Turkey	6010	597
Boğakşayan and Bakır (2013)	Turkey	5673	1935
Khattab et al. (2005)	Egypt	4746	2095
Makgahlela et al. (2007)	South Africa	8695	4112
Hashemi and Nayebpoor (2008)	Iran	5123	19885
Oudah and Zainab (2010)	Egypt	2737	1011
Pirzada (2011)	UK	7743	10768
Yousefi-Golverdi et al. (2012)	Iran	5662	1128
Bastin et al. (2013)	Belgium	8851	52147
Irano et al. (2014)	Brazil	9001	5090
Kheirabadi and Alijani (2014)	Iran	9059	763505

According to the Turkish Statistical Institute (TSI), while the number of cattle in Turkey was the highest in 1981 (15 981 000), the number was 13 994 071 in 2015. This indicates that, whereas Turkey had an important cattle potential in the past, this potential has reduced later. According to the statistics of the year 2015; 16 933 520 (90.77%) tones of the 18.654.682 tones milk annually produced in Turkey, were obtained from cattle (TSI, 2015). In this respect, cattle milk has an increased value as it has the highest share.

5.58% of the milk obtained from cattle was from indigenous breeds, 37.30% of it was from cross breeds and 57.12% of it was from culture breeds. As for the annual milk yield from cattle; around 1307 kg was from indigenous breeds, around 2677 kg was from cross breeds, around 3743 was from culture breeds and it was around 2581 kg in general (TSI, 2015).

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According to FAO (2017), cattle breeding is most common in Brazil with 214,889,796 animals. India ranks second with 185,103,532 animals and the USA ranks third with 93,704,600 animals. Turkey ranks twenty third in the world with 14 080 155 cattle. FAO (2017) also reported that, the USA ranks first in cattle milk production with 97 734 736 tones, India ranks second with 83,633,570 tones and Brazil ranks third with 33,490,810 tones. Turkey ranks ninth in the world by producing 18 762 319 tones cattle milk. These indicate that Turkey has a key role in cattle milk production.

The aim of the study is to examine the milk yields from indigenous, cross and culture breeds in 7 geographical regions of Turkey and to analyze the region-based variations in yearly milk yield.

Materials and methods

Material

Research material consisted of information obtained from the website of the Turkish Statistical Institute (TSI) with regards to the number of indigenous, cross and culture breeds cattle and the milk yield from these cattle, as presented on provincial-basis for the year 2015. Turkey Statistical Institute (TSI) of the data compiled by the relevant institutions (Ministry of Agriculture and Forestry) were taken from the records.

The amount of milk obtained from the cities of 7 geographical regions in Turkey was divided by the number of cattle milked, in order to calculate the average yearly milk yield. The values obtained were individually identified and analyzed for indigenous, cross and culture breeds. Statistical evaluations were made using IBM SPSS version 23.

Method

Multivariate analysis is performed when there are 2 or more dependent variables in each group with 2 or more members. In other words, mean vectors of more than 2 groups (in k) are compared (Alpar 2011). Comparison of the mean vector of k population for the MANOVA model (*Eq. 1;* Johnson and Wichern 2002):

$$Y_{ijk} = \mu + \alpha_{ij} + \varepsilon_{ijk} \qquad \text{(Eq.1)}$$

here, Y_{ijk} : is the k. observed value of the j. variable in i. population, α_{ij}: is the effect of j. variable in i. population, ε_{ijk}: is the error value in observed k. of the j. variable in i. Population.

Error terms (ε_{ijk}) have a normal distribution that are independent of each other, with zero means and $\sum$ covariance matrix (Jeremy 1974). $\bar{x}_i$: is the mean vector of i. group, $\bar{x}$: is the general mean vector, n_i: is the number of observations in i. group, S_i: is the variance-covariance vector in i. group (*Eqs. 2* and *3*):

$$B = \sum_{i=1}^{k} n_i (\bar{x}_i - \bar{x})(\bar{x}_i - \bar{x})' \qquad \text{(Eq.2)}$$

$$W = \sum_{i=1}^{k} (n_i - 1) S_i \qquad \text{(Eq.3)}$$

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Eigenvalues of the BW^{-1} matrix are λ_i. The largest root test statistics of Roy is the highest λ_i value.

Lawley-Hotelling trace test (*Eq. 4*):

$$T_0^2 = \sum_{i=1}^{s} \lambda_i \quad \text{(Eq.4)}$$

Pillai's Trace statistics (*Eq. 5;* Lehmann 1986):

$$T = \sum_{i=1}^{s} \lambda_i/(1+\lambda_i) \quad \text{(Eq.5)}$$

Here, s is the eigenvalue number. Wilks Lambda statistic is developed by Rao (1973) and is shown as (*Eq. 6*):

$$\Lambda = \prod_{i=1}^{s} 1/(1+\lambda_i) \quad \text{(Eq.6)}$$

One of the key hypotheses needed for the implementation of the multivariate analysis (MANOVA) is the homogeneity of the variance-covariance matrices. This is determined by the 'Box's M' test (*Eq. 7*).

$$M = \sum_{i=1}^{k}(n_i - 1)ln|S| - \sum_{i=1}^{k}(n_i - 1)ln|S_i| \quad \text{(Eq.7)}$$

In this Box's M statistic, S is the covariance matrix, S_i is the covariance matrix of each group (Özdamar 2013). For the multiple comparisons, paired comparisons regarding the Bonferroni approach are made in order to form simultaneous confidence intervals (Hsu 1996; Everitt 2001). Multiple test statistics are used in the multivariate analysis in order to test the H_o hypothesis. The Wilks Lambda test statistic presenting F distribution when the number of variables become 1, 2 for the first time, is the most common among these test statistics and calculated as such:

Wilks Lamda test statistic; *Equation 8* used in the calculation of the test variate F statistic is written as:

$$1 + \frac{\text{G.A.K.O}}{\text{G.İ.K.O}} \quad \text{(Eq. 8)}$$

and inverted for the multivariate B and W matrices, to obtain (*Eq. 9*):

$$\frac{1}{1+\frac{G.A.K.O}{G.\dot{I}.K.O}} = \frac{1}{1+\frac{B}{W}} = \frac{|W|}{|B+W|} = \Lambda \quad \text{(Eq.9)}$$

The Λ statistic here is called as the Wilks Lambda statistic.

In multivariate analysis, this ratio is used in place of the F statistic used in univariate analysis and takes a value between 0 and 1. If there is no group effect, Λ value is 1 if B = 0. Accordingly, the Ho hypothesis is accepted when Λ gets a value close to 1. If matrix B is bigger than matrix W, Λ value gets closer to zero (0). In this case, the Ho hypothesis is rejected. As in univariate analysis, there is a correlation between Λ and T^2 in multivariate analysis, too.

When k = 2 (*Eq. 10*):

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$$\Lambda = \frac{1}{1+\frac{T^2}{N-k}} \qquad \text{(Eq.10)}$$

When k = 2, Λ and T^2 statistics show p and N-p-1 freedom degree F distribution. When p = 1 (*Eq. 11*):

$$\Lambda = \frac{1}{1+B/W} = \frac{B}{W}\frac{N-k}{k-1} = F \qquad \text{(Eq.11)}$$

Results and discussion

Normal distribution of data and covariance matrices homogeneity test were performed based on the hypotheses needed for the covariate analysis (MANOVA). Outlier observations were found in the normality test (*Fig. 1*). Box's Test was performed in the equalities of covariance matrices.

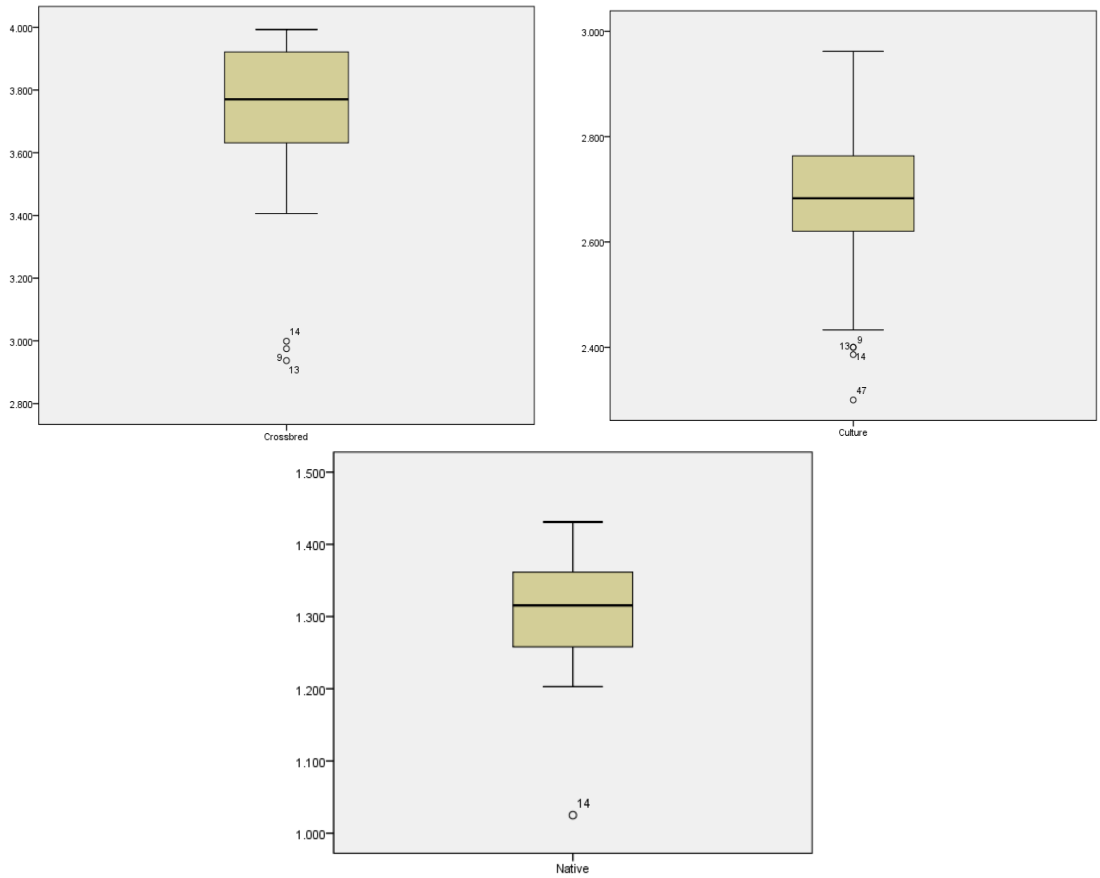

***Figure 1.** Outlier observation graph of data (yield-kg)*

As is seen in *Figure 1,* milk yield data of cross, culture and indigenous cattle show a normal distribution. In cross breed group, 9^{th}, 13^{th} and 14^{th} values are the outliers; in culture group, 9^{th}, 13^{th}, 14^{th} and 47^{th} values are the outliers whereas in indigenous group, 14^{th} value is the outlier. As Box's M = 74.391, F = 1.779 and p < 0.01 in Box's M Test as shown in *Table 2,* covariance matrices are not homogenous.

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Following the obtainment of these results, a reanalysis was performed after the removal of 9th, 13th, 14th and 47th outliers from the observed values since they were interrupting normality. The values belonged to the cities of Bingöl, Bitlis, Hakkari and Bartın. For this reason, Kilis, Bingöl, Bitlis, Hakkari and Bartın were excluded from the research and the research was performed with 76 cities. Q-Q Plot and outlier value graphs obtained from the normality tests performed for the new observations are given in *Figure 2.*

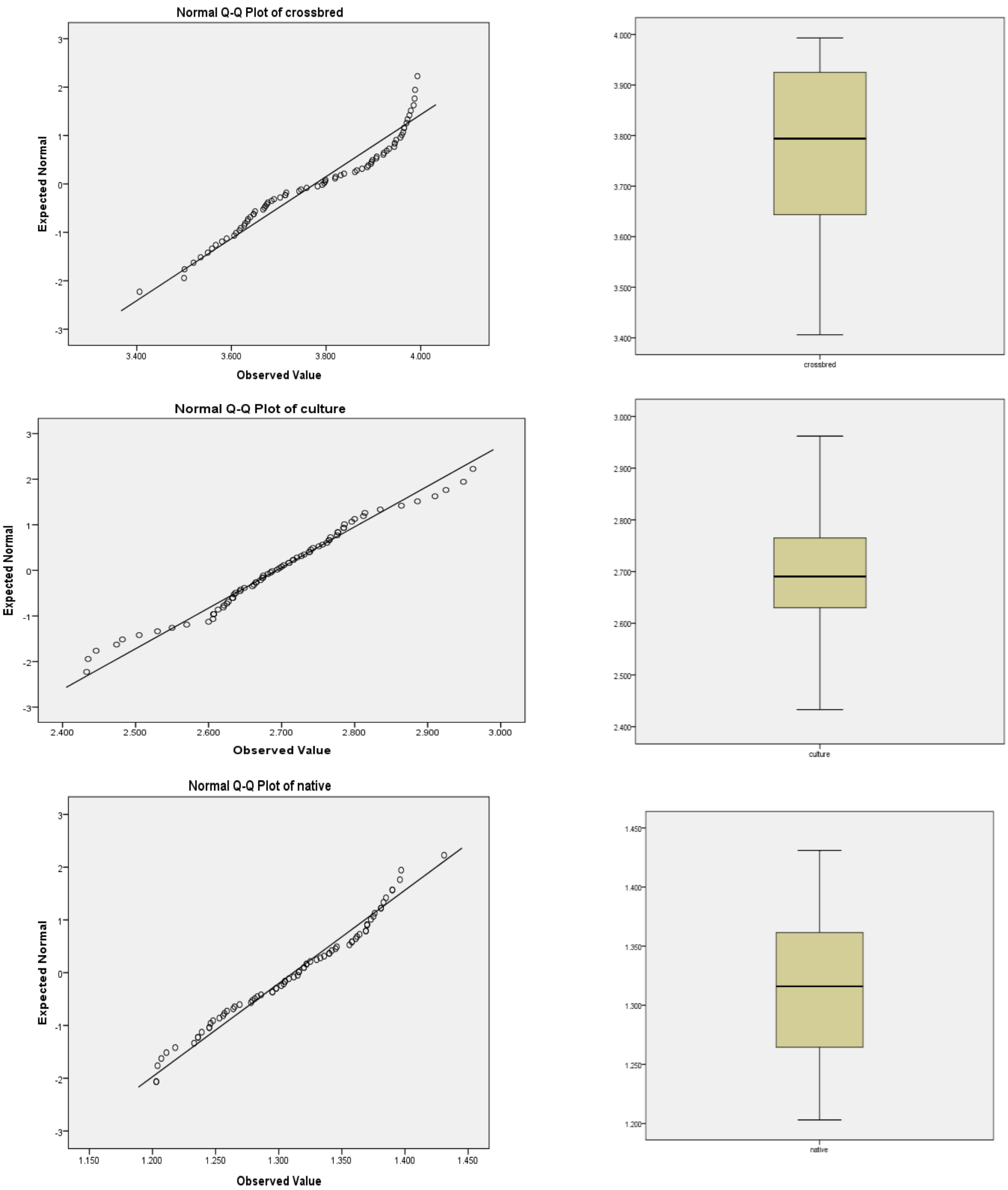

Figure 2. *Normal distribution and outlier observation graph of data*

As is seen in *Figure 2,* milk yield from cross, culture and indigenous cattle breeds show normal distribution according to Q-Q plot graph. This indicates that the outlier value problem has been resolved.

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At this point, homogeneity test for the covariance matrices of these data is presented in *Table 2* and test for sphericity is presented in *Table 3*.

***Table 2.** Box's M Test for the equality of the covariance matrices*

Box's M	74.391
F	1.779
df1	36
df2	5667.462
p	0.003

df: degrees freedom

***Table 3.** Box's Test for the equality of covariance matrices of groups*

Box's M	57
F	1.356
df1	36
df2	5677.983
p	0.076

H_0: Σ1 = Σ2 = Σ3; H_1: At least one of the group mean values is different from the others. Since p = 0.076 > α:0.05, H_0 cannot be rejected. Which means; group covariance matrices are equal. Therefore, MANOVA can be performed. In *Table 2*, Box's M = 57, F = 1.356 and p > 0.05, indicating that covariance matrices are homogenous. Test for sphericity is checked in *Table 4*.

***Table 4.** Bartlett's test for sphericity*

Likelihood Ratio	0.000
Approx. Chi-Square	53.611
df	5
p	0.001

In Barlett's test for sphericity shown in *Table 3*, Approx χ^2 = 53.611 and p < 0.01, indicating that MANOVA test can be performed. The assumption of normality is provided when the outlier values are omitted. Non-parametric tests are not necessary since appropriate analyzes can be performed with parametric statistics. Descriptive statistics are presented in *Table 5*. The table presenting representative statistics shows that milk yield from cross, culture and indigenous cattle present inter-regional differences.

The highest milk yield from cross breeds is obtained in the Aegean Region whereas the lowest milk yield is obtained in the Eastern Anatolia Region, the highest milk yield from culture breeds is obtained in the Aegean Region whereas the lowest milk is obtained in the Southeastern Anatolia Region, the highest milk yield from indigenous breeds is obtained in the Eastern Anatolia Regions whereas the lowest milk yield is obtained in the Mediterranean Region. MANOVA test results are presented in *Table 6*.

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Table 5. *Descriptive statistics*

Race	Region	$\bar{X}$	Range = Xmax-Xmin	S_X	$S_{\bar{X}}$	N
Culture	Eastern Anatolia	3670.273	163.740	100.480	41.039	11
	Southeastern Anatolia	3677.625	192.002	119.105	48.122	8
	Marmara	3889.182	163.740	79.625	41.039	11
	Aegean	3926.750	192.002	64.913	48.122	8
	Black Sea	3743.412	131.712	147.847	33.011	17
	Central Anatolia	3796.154	150.618	186.853	37.750	13
	Mediterranean	3753.250	192.002	175.830	48.122	8
	General	3776.355	163.740	156.156		76
Cross-bred	Eastern Anatolia	2715.182	135.728	153.598	34.018	11
	Southeastern Anatolia	2624.250	159.156	104.321	39.890	8
	Marmara	2699.818	135.728	137.858	34.018	11
	Aegean	2736.000	159.156	71.544	39.890	8
	Black Sea	2693.235	109.180	113.509	27.364	17
	Central Anatolia	2673.385	124.852	85.381	31.292	13
	Mediterranean	2708.375	159.156	81.703	39.890	8
	General	2692.803	65.058	112.176		76
Native	Eastern Anatolia	1343.455	76.288	26.170	16.306	11
	Southeastern Anatolia	1281.375	65.058	64.790	19.120	8
	Marmara	1298.000	76.288	47.862	16.306	11
	Aegean	1294.250	52.333	64.107	19.120	8
	Black Sea	1324.000	59.845	53.120	13.116	17
	Central Anatolia	1329.077	76.288	60.632	14.999	13
	Mediterranean	1278.500	135.728	59.320	19.120	8
	General	1311.513	159.156	56.576		76

$\bar{X}$: mean, S_X: standard deviation, $S_{\bar{X}}$: standard error

Table 6. *MANOVA test results*

Effect		Values	F	Hypothesis df	Residual df	p	Power of test
Region	Pillai's Trace	0.522	2.422	18	207	0.001	0.993
	Wilks' Lambda	0.546	2.518	18	190	0.001	0.991
	Hotelling's Trace	0.711	2.594	18	197	0.001	0.996
	Roy's Largest Root	0.490	5.634	6	69	0.001	0.995

df: degrees freedom

H_0: $\mu_1 = \mu_2 = \mu_3$; H_1: At least one of the group mean values is different from the others. Since p = Sig:0.001 < α:0.005, H_0 is rejected.

Within the framework of the results of the MANOVA test, Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root test results displayed significant inter-regional differences in milk yields from 3 different breeds (indigenous, cross and culture breeds) ($p < 0.01$). (This indicates that group mean vectors are significantly different.) Which means, according to Pillai's Trace statistic: $F = 2.422$, $P < 0.001$;

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according to Wilks' Lambda statistic: $F = 2.518$, $P < 0.001$; According to Hotelling's Trace statistic: $F = 2.594$, $P < 0.001$; according to Roy's Largest Root statistic: $F = 5.694$, $P < 0.001$.

Power of test values were very high. Power of test values for Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root tests were 99.3%, 99.1%, 99.6% and 99.5%, respectively. Minimum absolute frequency corresponding to a power rating of 80% is generally favorable (Mendeş 2013). In this respect, the findings of these statistical analyses are favorable. As stated above, it is greater than 80% and the power of the test is high. More than 80% of the power of the test indicates that the analysis is appropriate.

Bonferroni and Tukey Multiple Comparison Tests were performed to determine the inter-regional differences regarding milk yield from each breed. Bonferroni and Tukey test results are presented in *Table 7a, b* and *c*.

According to Bonferroni and Tukey test results, there were significant differences between the Eastern Anatolia-Marmara, Eastern Anatolia-Aegean, Southeastern Anatolia-Marmara and Southeastern Anatolia-Aegean regions with regards to average milk yield ($p < 0.05$ and $p < 0.01$). In this respect, milk yield obtained from culture cattle in the Aegean and Marmara regions was much higher than the milk yield obtained from other regions. Milk yield obtained from culture cattle in the Eastern Anatolia and Southeastern Anatolia regions was lower. The highest milk yield was obtained from the Aegean and Marmara regions, respectively. Conditions of Aegean and Marmara regions in Turkey were observed to be favorable for culture cattle. Inter-regional differences regarding average milk yield from crossbreed and indigenous breed cattle were insignificant, indicating that all regions of Turkey are favorable for crossbreed and indigenous breed cattle.

Likewise, when the present situation (2018 year) can be also analyzed, the obtained results are summarized as follows. The effects of breeds and regions on milk yield in cattle are presented in *Table 8*. MANOVA Tests results for region (*Table 8*): Wilk's Lambda: 0.548, Pillai trace: 0.520, Roy's largest root test: 0.487, Hotelling trace: 0.705. Approximate F test: 12.370* on 36 and 5677 d.f. (degrees freedom).

The results presented in *Table 8* show that the highest mean milk yields were experienced in Aegean, Marmara and Central Anatolia (3926.755, 3889.264 and 3796.178 kg respectively), which are greater than the general mean (3779.394 kg) in culture cattle. The lowest mean milk yield was recorded of 3670.258 kg in Eastern Anatolia. The differences in mean yield owing to region are confirmed by the F-ratio for milk yield ($F = 4.923$ and $P < 0.001$).

Aegean and Eastern Anatolia regions had the highest values for milk yield (2735.997 and 2715.171 kg respectively), while Southeastern Anatolia region recorded the least mean milk yield (2624.235) which is less than the general mean (2696.829 g) in crossbreed cattle. The difference between milk yields in crossbreed cattle by geographical regions was insignificant ($F = 0.997$ and $P > 0.05$).

Eastern Anatolia and Central Anatolia regions had the highest mean milk yield of native cattle (1343.499 and 1328.856 kg respectively) which are greater than the general mean (1309.437 kg), while Mediterranean region had a least mean milk yield of native cattle (1278.477 kg), less than the general mean. The difference between milk yields in native cattle by geographical regions was insignificant ($F = 1.952$ and $P > 0.05$).

Bonferroni Multiple Comparison Test was applied to examine the inter-regional differences regarding milk yield from culture cattle. Bonferroni test results are presented in *Table 9*.

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Table 7a. *Bonferroni and Tukey test results (for Culture)*

Group	Region		Means difference (I-J)	Std. error	P (for Bonferroni)	P (for Tukey)
Culture	Eastern Anatolia	Southeastern Anatolia	-7.352	63.245	0.999	0.999
		Marmara	-218.909*	58.037	0.007	0.006
		Aegean	-256.477*	63.245	0.003	0.002
		Black Sea	-73.139	52.668	0.999	0.806
		Central Anatolia	-125.881	55.760	0.570	0.280
		Mediterranean	-82.977	63.245	0.999	0.844
	Southeastern Anatolia	Marmara	-211.557*	63.245	0.028	0.022
		Aegean	-249.125*	68.055	0.010	0.008
		Black Sea	-65.787	58.357	0.999	0.917
		Central Anatolia	-118.529	61.162	0.999	0.463
		Mediterranean	-75.625	68.055	0.999	0.923
	Marmara	Aegean	-37.568	63.245	0.999	0.997
		Black Sea	145.770	52.668	0.152	0.097
		Central Anatolia	93.028	55.760	0.999	0.639
		Mediterranean	135.932	63.245	0.738	0.336
	Aegean	Black Sea	183.338	58.357	0.052	0.038
		Central Anatolia	130.596	61.162	0.762	0.940
		Mediterranean	173.500	68.055	0.273	0.999
	Black Sea	Central Anatolia	-52.742	50.148	0.999	0.940
		Mediterranean	-9.838	58.357	0.999	0.999
	Central Anatolia	Mediterranean	42.904	61.162	0.999	0.992

Table 7b. *Bonferroni test results (for Cross-bred)*

Group	Region		Means difference (I-J)	Std. error	P (for Bonferroni)	P (for Tukey)
Cross-bred	Eastern Anatolia	Southeastern Anatolia	90.932	52.425	0.999	0.596
		Marmara	15.364	48.109	0.999	0.999
		Aegean	-20.818	52.425	0.999	0.999
		Black Sea	21.947	43.658	0.999	0.999
		Central Anatolia	41.797	46.221	0.999	0.971
		Mediterranean	6.807	52.425	0.999	0.999
	Southeastern Anatolia	Marmara	-75.568	52.425	0.999	0.777
		Aegean	-111.750	56.413	0.999	0.436
		Black Sea	-68.985	48.373	0.999	0.786
		Central Anatolia	-49.135	50.699	0.999	0.959
		Mediterranean	-84.125	56.413	0.999	0.749
	Marmara	Aegean	-36.182	52.425	0.999	0.993
		Black Sea	6.583	43.658	0.999	0.999
		Central Anatolia	26.434	46.221	0.999	0.997
		Mediterranean	-8.557	52.425	0.999	0.999
	Aegean	Black Sea	42.765	48.373	0.999	0.974
		Central Anatolia	62.615	50.699	0.999	0.878
		Mediterranean	27.625	56.413	0.999	0.999
	Black Sea	Central Anatolia	19.851	41.569	0.999	0.999
		Mediterranean	-15.140	48.373	0.999	0.999
	Central Anatolia	Mediterranean	-34.990	50.699	0.999	0.993

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Table 7c. *Bonferroni test results (for Native)*

Group	Region		Means difference (I-J)	Std. error	P (for Bonferroni)	P (for Tukey)
Native	Eastern Anatolia	Southeastern Anatolia	62.080	25.129	0.335	0.186
		Marmara	45.455	23.060	0.999	0.442
		Aegean	49.205	25.129	0.999	0.450
		Black Sea	19.455	20.927	0.999	0.966
		Central Anatolia	14.378	22.155	0.999	0.995
		Mediterranean	64.955	25.129	0.249	0.147
	Southeastern Anatolia	Marmara	-16.625	25.129	0.999	0.994
		Aegean	-12.875	27.040	0.999	0.999
		Black Sea	-42.625	23.187	0.999	0.527
		Central Anatolia	-47.702	24.301	0.999	0.447
		Mediterranean	2.875	27.040	0.999	0.999
	Marmara	Aegean	3.750	25.129	0.999	0.999
		Black Sea	-26.000	20.927	0.999	0.875
		Central Anatolia	-31.077	22.155	0.999	0.799
		Mediterranean	19.500	25.129	0.999	0.987
	Aegean	Black Sea	-29.750	23.187	0.999	0.857
		Central Anatolia	-34.827	24.301	0.999	0.782
		Mediterranean	15.750	27.040	0.999	0.997
	Black Sea	Central Anatolia	-5.077	19.925	0.999	0.999
		Mediterranean	45.500	23.187	0.999	0.448
	Central Anatolia	Mediterranean	50.577	24.301	0.864	0.375

Table 8. *Summary of results of MANOVA test for regions across the milk yield*

Region	Culture, milk yield mean (kg)	Crossbreed milk yield mean (kg)	Native milk yield mean (kg)
Mediterranean	3753.273	2708.339	1278.477
Southeastern Anatolia	3677.567	2624.235	1281.331
Eastern Anatolia	3670.258	2715.171	1343.499
Marmara	3889.264	2699.791	1297.685
Aegean	3926.755	2735.997	1294.120
Black Sea	3756.949	2711.301	1315.155
Central Anatolia	3796.178	2673.365	1328.856
General mean	3779.394	2696.829	1309.437
S.E.D.	17.632	12.325	6.519
F-ratio region	4.923***	0.997 ns	1.952 ns

***, **, *: significant differences at the 0.001, 0.01 and 0.05 level of significance respectively. ns stands for not significant at 5% level of significance. S.E.D stands for standard error for differences. Power of test values for Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root tests were 99.3%, 99.1%, 99.6% and 99.5%, respectively. In short, the results of 2018 data and 2015 data were equal to each other

According to Bonferroni test results, there was significant differences between the Eastern Anatolia-Marmara, Eastern Anatolia-Aegean, Southeastern Anatolia-Marmara and Southeastern Anatolia-Aegean regions with regards to average milk yield ($p < 0.05$ and $p < 0.01$). Inter-regional differences regarding average milk yield from crossbreed and native cattle were insignificant.

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Table 9. *Bonferroni test results (for culture)*

	Eastern Anatolia	Southeastern Anatolia	Marmara	Aegean	Black Sea	Central Anatolia	Mediterranean
Eastern Anatolia	---	---	**	**	---	---	---
Southeastern Anatolia	---	---	*	**	---	---	---
Marmara	**	*	---	---	---	---	---
Aegean	**	**	---	---	---	---	---
Black Sea	---	---	---	---	---	---	---
Central Anatolia	---	---	---	---	---	---	---
Mediterranean	---	---	---	---	---	---	---

*P < 0.05, **P < 0.01

Similar results were obtained in the MANOVA test for 2015 and 2018 data. In both data sets, the power of the test gave the same results. Bonferroni test gave the same results for 2015 and 2018 data in determining the difference of milk yield by region.

Çelik (2015) used the MANOVA method to analyze the inter-regional differences with regards to milk yield from small cattle. Research findings presented statistically significant inter-regional differences with regards to milk yield from hair goat and indigenous sheep. As for milk yield from hair goat, there were significant differences between Eastern Anatolia-Southeastern Anatolia, Marmara, Aegean and Mediterranean regions, Southeastern Anatolia-Marmara, Aegean and Mediterranean regions, Marmara-Aegean regions, Middle Eastern Anatolia and Mediterranean regions, Aegean-Mediterranean regions, Middle Eastern Anatolia-Mediterranean regions and Mediterranean-Black Sea regions. As for milk yield from indigenous breed cattle, there were significant differences between Eastern Anatolia-Southeastern Anatolia, Marmara, Aegean, Middle Eastern, Mediterranean and Black Sea regions, Southeastern Anatolia-Marmara, Aegean, Middle Eastern, Mediterranean and Black Sea regions, Marmara-Aegean regions, Middle Eastern Anatolia, Mediterranean and Black Sea regions, Aegean-Middle Eastern, Mediterranean and Black Sea regions and Middle Eastern Anatolia-Black Sea regions.

Indigenous, cross and culture breed animals in Turkey were compared with respect to 11 slaughtering and 18 carcass features and MANOVA analysis was performed. The differences among culture, indigenous and cross breeds were significant with regards to culture breeds (Kızıl and Aydoğan 2014).

In agricultural sciences, MANOVA test has been applied (Engeler and Reyer 2000, Woodward and Bauer 2007, Maposa et al. 2010, Turan 2011).

In this research, studies on other animal breeding data were analyzed using the MANOVA method.

Conclusion

In this research, milk yields from culture, cross and indigenous breed cattle in Turkey were analyzed by multivariate analysis (MANOVA) for 7 geographical regions. In this research, 7 groups (regions) were subjected to MANOVA test on the basis of 3 dependent variables (breeds). The cities of Kilis, Bingöl, Bitlis, Hakkari and Bartın were excluded from the research as they interrupted the observation values of the normality test. Analysis was performed for 76 cities and the observed outlier value was

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eliminated. After this stage, homogeneity test for the covariance matrices and sphericity test were presented with the aim to apply the MANOVA test. As $p = 0.076 > \alpha = 0.05$ according to the results of the test, group covariance matrices were equal. As Approx $\chi^2 = 53.611$ and $p < 0.01$ according to the result of the Barlett's Test for Sphericity, MANOVA test was determined to be suitable for the analyzed data set. Representative statistical analysis was performed to show that milk yield from cross, culture and indigenous breeds varied on regional basis. While a higher milk yield was reported for cross breed cattle in the Aegean Region, the lowest milk yield was reported for the Eastern Anatolia Region. As for culture breed cattle, the highest milk yield was obtained in the Aegean Region whereas the lowest milk yield was obtained in the Southeastern Anatolia Region. As for indigenous breed cattle, the highest milk yield was obtained in the Eastern Anatolia Region whereas the lowest milk yield was obtained in the Mediterranean Region. According to the results of the Bonferroni test, milk yield differences from cross breed cattle were significant between the Eastern Anatolia-Aegean regions, Eastern Anatolia-Marmara regions, Southeastern Anatolia-Aegean regions and Southeastern Anatolia-Marmara regions. The inter-regional differences observed in milk yield obtained from culture breed and indigenous breeds cattle were insignificant. In general, milk yield from cross and culture breeds cattle was higher in Aegean and Marmara regions whereas milk yield from indigenous breed cattle was higher in the Eastern Anatolia region. Statistical methods proved to be favorable in the research, enabling the essential hypotheses. Consequently, MANOVA test can be considered to be a powerful analysis method in this research. The MANOVA test was determined to be good predictors of the difference of milk yield between regions in agriculture. It can be recommended that the use multivariate statistical methods of such as MANOVA method will be beneficial in future studies in agriculture.

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REFERENCES

[1] Akman, N., Şen, A. Ö., Cedden, F. (2017): Türkiye'de sığır yetiştiriciliği. – Tarım Haftası 2017 Türkiye'nin Hayvansal Üretimi (Mevcut Durum ve Gelecek) Sempozyumu, 10-11 Ocak 2017, pp. 55-75, Ankara, Türkiye.
[2] Alpan, O., Arpacık, R. (1998): Sığır Yetiştiriciliği. – Medisan, Ankara.
[3] Alpar, R. (2011). Uygulamalı Çok Değişkenli İstatistiksel Yöntemler. – Detay Yayıncılık, Ankara.
[4] Bakır, G., Kaygisiz, A., Çilek, S. (2009): Milk yield of Holstein cattle reared at Tahirova State Farm in Balikesir Province in Turkey. – Journal of Animal and Veterinary Advances 8(11): 2369-2374.
[5] Bastin, C., Soyeurt, H., Gengler, N. (2013): Genetic parameters of milk production traits and fatty acid contents in milk for Holstein cows in parity 1–3. – J. Anim. Breed. Genet. 130: 118-127.
[6] Boğokşayan, H., Bakır, G. (2013): Determination of lifetime yield performance of Holstein cattle raised in Şanlıurfa Ceylanpınar farm. – Atatürk University Journal of the Agricultural Faculty 44(1): 75-81 (Turkish).
[7] Çelik, Ş. (2015): Investigation milk yield in small ruminants by region in Turkey. – International Journal of Innovation Sciences and Research 4(10): 516-519.

[8] Duru, S., Kumlu, S., Tuncel, E. (2012): Estimation of variance components and genetic parameters for type traits and milk yield in Holstein cattle. – Turk. J. Vet. Anim. Sci. 36(6): 585-591.
[9] Engeler, B., Reyer, H-U. (2000): Choosy females and indiscriminate males: mate choice in mixed populations of sexual and hybridogenetic water frogs (*Rana lessonae, Rana esculenta*). – Behavioral Ecology 12(5): 600-606.
[10] Everitt, B. S. (2001): Statistics for Psychologists. An Intermediate Course. – Lawrance Erlbaum Associates, Inc., New Jersey.
[11] FAO (2017): Food and Agriculture Organization of the United Nations. Live Animal Production. – http://faostat3.fao.org/download/Q/QL/E.
[12] Hsu, J. C. (1996): Multiple Comparisons. – CRS Press LLC, New York.
[13] Jeremy, D. F. A. (1974): General Model for Multivariate Statistical Analysis. – Prentice-Hall International, Inc, USA.
[14] Johnson, R. A., Wichern, D. W. (2002): Applied Multivariate Statistical Analysis. – Prentice Hall, Upper Saddle River, NJ.
[15] Hashemi, A., Nayebpoor, M. (2008): Estimates of genetic and phenotype parameters from milk production in Iran Holstein-Friesian cows. – Research Journal of Biological Sciences 3(6): 678-682.
[16] IBM Corp. Release (2015): IBM SPSS Statistics for Windows, Version 23.0. – IBM Corp, Armonk, NY.
[17] Irano, N., Braga Bignardi, A., El Faro, L., Luiz Santana M, Lúcia, C. V., Albuquerque, L. G. (2014): Genetic association between milk yield, stayability and mastitis in Holstein cows under tropical conditions. – Trop. Anim. Health Prod. 46: 529-535.
[18] Keskin, İ., Boztepe, S. (2011): Estimation of 305 days milk yield using partial milk yield in Holstein cattle. – Tekirdağ Ziraat Fakültesi Dergisi 8(1): 1-7.
[19] Khattab, A. S., Atil, H., Badawy, L. (2005): Variances of direct and maternal genetic effects form milk yield and first calving in a herd of Friesian cattle in Egypt. – Arch. Tierz. 48(1): 24-31.
[20] Kheirabadi, K., Alijani, S. (2014): Genetic parameters for milk production and persistency in the Iranian Holstein population by the multitrait random regression model. – Archiv Tierzucht 57(12): 1-12.
[21] Kızıl, S. H., Aydoğan, M. (2014): Evaluation of major cattle breeds in Turkey for slaughter and carcass traits using MANOVA and multidimensional scaling technique. – Journal of Faculty of Veterinary Medicine, Erciyes University 11(1): 15-22.
[22] Kumlu, S., Akman, N. (1999): Milk yield and reproductive traits of Holstein Friesian breeding herds in Turkey – Lalahan Hayvancılık Araştırma Enstitüsü Dergisi 39(1): 1-15 (Turkish).
[23] Lehmann, E. L. (1986): Testing Statistical Hypotheses. Wiley Series in Probability and Mathematical Statistics. – Wiley, New York.
[24] Makgahlela, M. L., Banga, C. B., Norris, D., Dzama, K., Ng'ambi, J. W. (2007): Genetic correlations between female fertility and production traits in South African Holstein cattle. – South African Journal of Animal Science 37(3): 180-188.
[25] Maposa, D., Mudimu, E., Ngwenya, O. (2010): A multivariate analysis of variance (MANOVA) of the performance of sorghum lines in different agroecological regions of Zimbabwe. – African Journal of Agricultural Research 5(3): 196-203.
[26] Mendeş, M. (2013): Uygulamalı Bilimler İçin İstatistik ve Araştırma Yöntemleri. – Kriter Yayınevi, İstanbul.
[27] Oudah, E. Z. M., Zainab, A. K. (2010): Genetic evaluation for Friesan cattle in Egypt using single-trait animal model. – Journal Animal and Poultry Production, Mansoura University 1(9): 371-381.
[28] Pirzada, R. (2011): Estimation of genetic parameters and variance components of milk traits in Holstein-Friesian and British-Holstein dairy cows. – Kafkas Üniversitesi Veteriner Fakültesi Dergisi 17(3): 463-467.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1706_1494514959

[29] Rao, C. R. (1973): Linear Statistical Inference and Its Applications. 2nd. Ed. – John Wiley & Sons Inc, New York.

[30] Şahin, A., Ulutaş, Z. (2010): Genetic parameters of milk production and reproduction traits of Holstein cattle at a Tahirova State Farm conditions. – Kafkas Üniversitesi Veteriner Fakültesi Dergisi 16(6): 1051-1056.

[31] Şapdeniz, İ. (1993): A research on the economic analysis and the physical input requirements on the dairy enterprise of the Agriculture Faculty of Ankara University. – Ankara University Graduate School of Natural and Applied Sciences Department of Agricultural Economics, Master’s thesis, Ankara (Turkish).

[32] Sattar, A., Mirza, R. H., Niazi, A. A. K., Laitf, M. (2005): Productive and reproductive performance of Holstein-Friesian cows in Pakistan. – Parkistan Vet. J. 25(2): 75-81.

[33] Tekerli, M., Gündoğan, M. (2005): Effect of certain factors on productive and reproductive efficiency traits and phenotypic relationships among these traits and repeatabilities in West Anatolian Holsteins. – Turk J. Vet. Anim. Sci. (29): 17-22.

[34] Tuncel, E. (1994): Hayvan Islahı. – Uludağ Üniversitesi Ziraat Fakültesi Ders Notları No: 46, Bursa.

[35] Turan, H. (2011): Geometric Morphometric studies Trakya Region honeybees (*Apis mellifera L.).* – Ph.D. Thesis. Namık Kemal University Graduate School of Natural and Applied Sciences Main Science Division of Animal Science (Turkish).

[36] TSI (2015): Animal Production Statistics, Animal Products, Number of Milked Animals and Milk Production Quantity. – Turkish Statistical Institute, Ankara (Turkish). http://www.tuik.gov.tr/PreTablo.do?alt_id=1002 (accessed to 26.10.2016).

[37] Türkyılmaz, M. K. (2005): Reproductive characteristics of Holstein cattle reared in a private dairy cattle enterprise in Aydın. – Turk J. Vet. Anim. Sci. 29: 1049-1052.

[38] Woodward, L. E., Bauer, A. L. (2007): People and their pets: a relational perspective on interpersonal complementarity and attachment in companion animal owners. – Society and Animals 15: 169-189.

[39] Yaylak, E. (2003): Reasons for culling, herd life and productive life in Holstein cows – Akdeniz Üniversitesi Ziraat Fakültesi Dergisi 16(2): 179-185 (Turkish).

[40] Yousefi-Golverdi, A., Hafezian, H., Chashnidel, Y., Farhadi, A. (2012): Genetic parameters and trends of production traits in Iranian Holstein population. – African Journal of Biotechnology 11(10): 2429-2435.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1706_1494514959