The Journal of Animal & Plant Sciences, 26(1): 2016, Page: 63-68
ISSN: 1018-7081

COMPARISON OF THE SENSORY CHARACTERISTICS IN AWASSI AND RED KARAMAN SHEEP WITH THE GREY RELATIONAL ANALYSIS METHOD

M. Topal[1*], M. Ozdemir[1], A. M. Yaganoglu[1] and N. Esenbuga[2]

[1] Biometry and Genetics Unit, [2] Animal Raising Unit, Department of Animal Science, Faculty of Agriculture, Ataturk University, 25240 Erzurum, Turkey
[1]Corresponding author: Mehmet Topal, Atatürk University, Agriculture Faculty, Department of Animal Science, Biometry and Genetics Unit 25240 Erzurum, Turkey.
Corresponding Author e-mail: mtopal@atauni.edu.tr

ABSTRACT

The grey system theory is a method which is used in situations when various assumptions are not valid in the application of parametric statistical analysis methods. The grey relational analysis is one of the subtopics of the grey system theory and defined as the grading, categorization and decision-making in the data set by using the Grey Relation Coefficient (GRG). In this study, the sensory analysis results of the samples obtained from the Longissimus Dorsi (LD), triceps brachi (TB) and semitendinosus (SMD) muscles of the Awassi and Red Karaman sheep breeds were tried to be researched by using the Grey Relational Analysis together with which ones were more preferred in terms of breed and muscle type. At the end of the study, no difference was observed between the preferability degrees of the Awassi (GRG=0.589) and Red Karaman (GRG=0.595) breeds. It was found that there was no important difference between the muscles as per the GRG relation coefficient, but the most preferred muscles were SMD (0.607), LD (0.589) and TB (0.578), respectively. It was determined in the sensory analysis made within this study that the most important factors distinguishing the preferability status of the mutton were WBS (0.729), juiciness (0.658), tenderness (0.581), NCBS (562), flavour (0.532) and acceptability (486), respectively.

Keywords: Gray relational analysis, Sensory analysis, Awassi, Red Karaman.

INTRODUCTION

Various assumptions such as the homogeneity of the variances, compliance of the data distribution with the normal distribution and adequacy of the sample size must be valid in the application of parametric statistical analysis methods. When these assumptions are not valid, either the nonparametric statistical methods or the parametric methods in which the normal distribution supposition is not valid are used. One of the nonparametric methods used when the sample size is not adequate is the grey relational analysis method; the supposition related to the compliance of the data with any distribution is not valid in this method and it can be applied to the data obtained both through the discrete, i.e. ordinal scale and the continuous, i.e. interval and ratio scales. The grey relational analysis is a method that can be used in situations especially when the sample size is small in the field of animal breeding and improvement or the examined animals must be evaluated individually. It's a method which can make comparisons between the individuals or groups by grading and categorizing individually or as a group when the animals must be selected considering their one or more than one certain character together. The grey relation coefficient (GRA), which is calculated with simple mathematical operations and interpreted very easily, enables especially the comparison of the livestock individually and can be used in selection studies requiring the good or bad animal selection.

Many studies were conducted on meat in terms of Sensory analyses. Keskin *et al*. (2012) used the procrustes analysis method to research the relation between the sensory variables, species, feeding systems and panelists in goats and sheep. Grajales-Lagunes *et al*.(2012) evaluated the effect of lactic acid treatment method in pork *Serratus ventralis* muscle on meat quality parameters pH, color, weight loss, cooking loss, hardness, and taste. Huuskonen *et al*. (2010) compared the color, chemical composition, meat quality and fatty acid profile of the *Longissimus dorsi* muscle of growing bulls housed in an insulated tie-stall, an uninsulated barn or a forest paddock. Esenbuga *et al*. (2001) worked on the sensory analysis in *Longissimus dorsi* and *Semimembranosus* muscles in the genotypes of Awassi, Red Karaman, Tushin and Awassi X Tushin. Esenbuga *et al*. (2009) studied on meat quality characteristics and sensory evaluation in different muscles of Awassi and Red Karaman lambs. Santos-Silva and Vaz Portugal (2001) researched the tenderness, juiciness and flavour characteristics in *Longissimus thoracis* muscles of the Serra da Estrela and Merino Branco lambs.

In this study, the sensory analysis results of the samples obtained from the *Longissimus dorsi* (LD), triceps brachi *Triceps brachi* (TB) and *Semitendinosus*

(SMD) muscles of the Awassi and Red Karaman sheep breeds were tried to be researched by using the grey relational analysis together with which ones were more preferred in terms of breed and muscle type.

MATERIALS AND METHODS

As material, 44 Awassi and 27 Red Karaman sheep were used, which were raised in the Research Farm of College Agriculture, Ataturk University. Muscle samples were taken from each sheep, cooked and evaluated by 7 individuals in terms of Warner Bratzler Shearforce(WBS), tenderness, juiciness, flavour, acceptability and the Number of chews before swallow(NCBS). The degrees included in the evaluation form according to the Likert scale were tenderness (Too Tender 9, Very Tender 8, Medium-level Tender 7, Less Tender 6, Neither Tender nor Hard 5, Less Hard, 4, Medium-level Hard 3, Very Hard 2, Too Hard 1), juiciness (Too Juicy 9, Very Juicy 8, Medium-level Juicy 7, Less Juicy 6, Neither Juicy nor Dry 5, Less Dry 4, Medium-level Dry 3, Very Dry 2, Too Dry 1), flavour (Too Much Flavour 9, 8, 7, 6, Medium-level Flavour 5, Less Flavour 4, 3, 2, 1) and acceptability (Good 9, 8, 7, 6, Medium 5, Bad 4, 3, 2, 1). For each muscle of each sheep, the average of the 7 individuals' evaluation results was considered.

The grey system theory is a method developed by Ju-Long Deng in 1982 and used to eliminate the uncertainty in data sets. This method does not require any distribution assumption and especially adequate sample size (Deng, 1982; Xia *et al*., 2012). The grey systems can be divided into three types as black system, white system and grey system. The black color means that the information is not known, the white color means the information is known completely and the grey color means the information is not known completely; it is between black and white. The grey relational analysis is one of the subtopics of the grey system theory and a method of grading, categorization and decision-making (Baş and Çakmak, 2012). The grey relation coefficient is valued between 0 and 1. If it is close to 1, this shows that the relation between the real values and reference values is high. If it is close to 0, then it indicates the relation is low (Hsu and Huang, 2006).

The grey relational analysis consists of the following steps (Deng, 1982; Hsu and Huang, 2006).

1- Generation of the reference data series ($\chi_0(k)$) and Comparison data series ($\chi_i(k)$).

$\chi_0(k) = (\chi_0(1), \chi_0(2), \ldots, \chi_0(n))$ k=1, 2, …, n

where n is the number of respondents.

$\chi_i(k) = (\chi_i(1), \chi_i(2), \ldots, \chi_i(n))$ k=1, 2, …, n; i=1, 2, …, m

the comparison data series consists of n values and m is number of values.

2- Normalization of the data (when necessary)

When the measurement units of the examined factors are different, the units of the factors must be converted into the same measurement unit before the gray relational analysis is conducted. Besides, normalization must also be applied if the range of the data set is high or the absolute standard values are too big. There are three types of normalization:

The maximum approach is suitable for the higher the better expectancy. *The higher the better*

$$x_i(k) = \frac{x_i^0(k) - \min x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)}$$

where $x_i(k)$ and $x_i^0(k)$ denote the normalized and orijinal values of the *i*th data series, respectively. The $\min x_i^0(k)$ is $\max x_i^0(k)$ representing the minimum and maximum values of the *i*th data series, respectively.

The minimum approach is suitable for the lower the better expectancy. *The lower the better*

$$x_i(k) = \frac{\max x_i^0(k) - x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)}$$

The objective approach is between the range of the minimum and maximum expectancy. *The most ideal value the best*

$$x_i(k) = 1 - \frac{|x_i^0(k) - x^0|}{\max x_i^0(k) - x^0}$$

where χ^0 is the objective value of the data series.

Values change between 0 and 1 as a result of the normalization. If small values are desired in the series, "the lower the better" normalization method is used and bigger valued points take values close to "0" while small ones take values close to "1" in the linear normalization. While the most ideal the better (the objective approach) method was used for the tenderness, juiciness and WBS values in the normalization process, the lowest the best (the minimum approach) method was used for flavour and NCBS in the normalization process and the highest the best (the maximum approach) method for the acceptability in the normalization process.

3- The coefficient matrix is formed by considering the different values between the comparison data set and the reference data set

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|$$

4- The smallest and the biggest values are determined in the coefficient matrix

$$\Delta_{min} = \forall j^{min} \in i \forall k^{min} |x_0(k) - x_j(k)|$$

$$\Delta_{max} = \forall j^{max} \in i \forall k^{max} |x_0(k) - x_j(k)|$$

5- The grey relation coefficient of each observation is calculated as follows;

$$\varepsilon\left(x_0(k), x_j(k)\right) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{0i}(k) + \xi\Delta_{max}}$$

Where k=1, 2, …, n, i=1, 2, …, m, j=1, 2, …, m, ξ $\epsilon(0,1)$. ξ is the distinguishing coefficient that adjusts the difference between Δ_{0i} and Δ_{max} and is suggested as 0.5.

ξis valued between 0 and 1, and it is the divisive coefficient (the distinguishing coefficient) setting the difference between Δ_{0i} and Δ_{max}. It is generally considered as 0.5.

6- The grey relational grade is determined by finding the average of the grey relation coefficients. The gray relational grade (GRG) is obtained by

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \varepsilon\left(x_0(k), x_j(k)\right)$$

The magnitude of the grey relational grade reflects the general grade of the standard deviation of the original data series from the i. reference data series (Wu, 2007).

Xuerui *et al*. (2007) and Xiaojun *et al*. (2010) defined the following by using the standard deviation of the GRG to find the lower and upper limits of the grey relational grade (GRG):

Considering the standard deviation of the grey relational grade as

$$\varepsilon\left(x_0(k), x_j(k)\right) = \varepsilon_i$$

$$S_{\gamma_i} = \sqrt{\left[\sum_{i=1}^{n} (\varepsilon_i - \gamma_i)^2\right]/(n-1)}$$

Lower and upper limits of the grey relational grade;

The lower limit is calculated as

$$\gamma_i - S_{\gamma_i}$$

The upper limit is calculated as

$$\gamma_i + S_{\gamma_i}$$

It was stated that the GRG with a bigger upper limit was more important than the other GRG when the GRGs were compared in terms of the lower and upper limits, otherwise, it was unimportant. This was defined as follows (Xuerui *et al*. 2007);

1- γ_a and γ_b will be considered as the GRGs of χ_a and χ_b, respectively

If $\gamma_a > \gamma_b$, then χ_a is superior to χ_b.

2- $\gamma_a \pm S_{\gamma a}$ and $\gamma_b \pm S_{\gamma b}$, If $\gamma_a > \gamma_b$ and

$(\gamma_a + S_{\gamma a}) > (\gamma_b + S_{\gamma b})$ and $(\gamma_a - S_{\gamma a}) > (\gamma_b - S_{\gamma b})$

then χ_a is accurately superior to χ_b.

3- $\gamma_a \pm S_{\gamma a}$ and $\gamma_b \pm S_{\gamma b}$, If $\gamma_a > \gamma_b$ and

$(\gamma_a + S_{\gamma a}) < (\gamma_b + S_{\gamma b})$ and $(\gamma_a - S_{\gamma a}) > (\gamma_b - S_{\gamma b})$or

$(\gamma_a + S_{\gamma a}) > (\gamma_b + S_{\gamma b})$ and $(\gamma_a - S_{\gamma a}) < (\gamma_b - S_{\gamma b})$

then χ_a is wrongly superior to χ_b.

RESULTS AND DISCUSSION

The lower and upper limits of the grey relational grade (GRG) show the whitening interval of the present variable. The approach of the coefficient to zero represents the blackening of the variable, in other words, that the relation between the real values and the reference values is low; its approach to 1 shows whitening, which means that the relation between the real values and the reference values is high. The more the lower and upper limits of the GRG approach one, the more the importance of the variable belonging to that coefficient increases.

It is seen that the difference between the GRG values (0.577 and 0.576 respectively) of the LD and TB muscles is very low while it is observed that the SMD muscles is more preferred than the LD and TB muscles according to the GRG in the Awassi sheep. Therefore, it can be said that there is no significant difference between the LD and TB muscles. When a comparison was made as per the lower and upper limits of the GRGs, the preferability order was TB, LD and SMD in terms of the lower limits, but it was SMD, LD and TB in terms of the upper limits. This shows that the order between the preferability statuses of the muscles is unimportant, that is, there is no difference between the preferability statuses of the muscles. While the preferability order of the muscles was LD, SMD and TB according to the GRG values in the Red Karaman sheep, the quite smallness of the difference between the biggest GRG value (0.607) and the smallest GRG value (0.580) indicates that there is no significant difference between the preferability of the muscles according to the GRG. When the lower limits were considered, preferability order was TB, SMD and LD. But it was LD, SMD and TB when the upper limits were taken into account. Hence, we cannot mention about a superiority or weakness between the preferability statuses of the LD, TB and SMD muscles according to the GRG values of the muscles in the Red Karaman sheep. According to Xuerui *et al*. (2007), the difference between the lower and upper limits must be big beside the greatness of the GRG values in order to express a certain superiority in the GRG values.

According to the Table 1, the most determinative characteristics in the LD muscle were found as 0.770 WBS, 0.665 NCBS, 0.560 juiciness, 0.513 acceptability, 0.490 Flavour and 0.464 tenderness respectively as per the grey relation coefficients in the Awassi sheep.

The most determinative characteristics in the TB muscle were found as 0.712 WBS, 0.671 juiciness, 0.567 NCBS, 0.538 tenderness, 0.492 flavour and 0.479 acceptability, respectively. The most determinative characteristics in the SMD muscle were obtained as 0.809 Tenderness, 0.739 juiciness, 0.727 WBS, 0.551 flavour, 0.446 NCBS and 0.404 acceptability, respectively.

In Awassi sheep, the most determinative characteristics in the LD, TB and SMD muscles were found as 0.736 WBS, 0.659 juiciness, 0.606 Tenderness, 0.557 NCBS, 0.511 flavour and 0.464 acceptability respectively as per the grey relation coefficients. Thus, it can be said that the WBS, juiciness and tenderness are important characteristics in meat in terms of quality.

Table 1: The grey relational grade (GRG) and mean gray relational coefficients (MGRC) of sensory variables in different muscles of Awassi and Red Karaman lambs

Breed	Muscle	N	GRC						GRG	S_{γ_i}	$\gamma_i \pm S_{\gamma_i}$
			WBS	Tenderness	Juiciness	Flavour	Acceptability	NCBS	γ_i		
Awassi	LD	14	0.770	0.464	0.560	0.490	0.513	0.665	**0.577**	0.161	0.416-0.738
	TB	15	0.712	0.538	0.671	0.492	0.479	0.567	**0.576**	0.148	0.428-0.724
	SMD	15	0.727	0.809	0.739	0.551	0.404	0.446	**0.613**	0.199	0.414-0.812
	MGRC	44	0.736	0.606	0.659	0.511	0.464	0.557	**0.589**	0.171	0.418-0.760
Red Karam	LD	9	0.661	0.517	0.650	0.665	0.576	0.575	**0.607**	0.180	0.427-0.787
	TB	9	0.763	0.449	0.570	0.511	0.549	0.638	**0.580**	0.146	0.434-0.726
	SMD	9	0.734	0.653	0.750	0.517	0.439	0.500	**0.599**	0.171	0.428-0.770
	MGRC	27	0.719	0.540	0.657	0.564	0.521	0.571	**0.595**	0.166	0.429-0.761
Total	LD	23	0.727	0.484	0.595	0.558	0.537	0.630	**0.589**	0.169	0.420-0.758
	TB	24	0.731	0.504	0.633	0.499	0.505	0.594	**0.578**	0.147	0.431-0.725
	SMD	24	0.730	0.750	0.743	0.539	0.417	0.466	**0.607**	0.189	0.418-0.796
	GRG	71	**0,729**	**0.581**	**0.658**	**0.532**	**0.486**	**0.562**	**0.591**	0.169	0.422-0.760
	S_{γ_i}		0.153	0.184	0.167	0.115	0.123	0.142			
	$\gamma_i \pm S_{\gamma_i}$		0.576-0.882	0.397-0.765	0.491-0.825	0.417-0.647	0.363-0.609	0.420-0.704			

γ_i: The grey relational grade; $S_{\gamma i}$: Standart deviation of GRG; $\gamma_i \pm S_{\gamma i}$: Lower and upper limit LD: Longissimusdorsi muscle; TB: Triceps brachi muscle (TB); SMD:Semitendinosus muscle; WBS: Warner BratzlerShearforce, NCBS: Number of chews before swallow

The closeness of the GRG coefficient to 1 shows that the relation between the real values and reference values is high; its closeness to 0 indicates that the relation between the real values and reference values is low. It can be stated accordingly that the real values are close to the reference values in terms of WBS, juiciness and tenderness, but far especially in terms of the acceptability in the Awassi sheep.

According to the Table 1, the most determinative characteristics in the LD muscle were found as 0.665 flavour, 0,661 WBS, 0.650 juiciness, 0.576 acceptability, 0.575 NCBS and 0.517 tenderness respectively as per the grey relation coefficients in the Red Karaman sheep, whereas the most determinative characteristics in the TB muscle were obtained as 0.763 WBS, 0.638 NCBS, 0.570 juiciness, 0.511 flavour, 0.549 acceptability and 0.449 tenderness, respectively. The most determinative characteristics in the SMD muscle were found as 0.750 juiciness, 0.734 WBS, 0.653 tenderness, 0.517 flavour, 0.500 NCBS and 0.439 acceptability, respectively.

In the Red Karaman sheep, the most determinative characteristics in LD, TB and SMD muscles were found as 0.719 WBS, 0.657 juiciness, 0.571 NCBS, 0.564 flavour, 0.540 tenderness and 0.521 acceptability respectively according to the GRA coefficients. It can be said that the closeness of the NCBS, flavour, tenderness and acceptability characteristics to the reference values is similar to each other while the real values are close to the reference values in terms of WBS, juiciness and tenderness in the Awassi sheep. Hence, it can be stated that the WBS and juiciness are important distinguishing characteristics in the mutton of the Red Karaman sheep in terms of quality.

When breed and muscles were together investigated, the most important distinguishing characteristics in the mutton were found as 0.729 WBS, 0.658 juiciness, 0.581 tenderness, 0.562 NCBS, 0.532 flavour and 0.486 acceptability respectively as per the GRG coefficients. Considering the lower and upper limits of the GRG values meanwhile, the lower and upper limits of the WBS were found high as 0.576 - 0.882, and secondly, the lower and upper limits of Juiciness were found high as 0.491 – 0.825. The most important sensory characteristics, which determine the preferability status of muscles, were respectively found as 0.576 WBS, 0.491 juiciness, 0.420 NCBS, 0.417 flavour, 0.397 tenderness and 0.363 acceptability according to the lower limits of the CRC values, and as 0.882 WBS, 0.825 juiciness, 0.765 tenderness, 0.704 NCBS, 0.647 flavour and 0.609 acceptability according to the upper limits of the CRC values. In view of these results, it can be stated that the LD, TB and SMD muscles of the lambs from Awassi and Red Karaman breeds included in the experiment have WBS and juiciness statuses close to the desired level, their tenderness, NCBS and flavour characteristics are at the middle level, but their acceptability characteristics is not at the preferred level.

Although it seems that the Red Karaman (GRG=0.595) is more preferred than the Awassi (GRG=0.589), no difference was observed between the preferability degrees of the breeds considering the fact that their GRG coefficients were quite close to each other. Considering the confidence limits of the GRG coefficients belonging to the both breeds, the lower and upper limits of the GRG coefficient of the Red Karaman were found higher than the lower and upper limits of the GRG coefficient of the Awassi, but it is seen that this difference is not so important, and therefore, the lower and upper limits of the both breeds' GRG coefficients are quite close to each other. When the Table 1 is checked,

no obvious difference is seen between the breeds in terms of the sensory characteristics according to the grey relation coefficients. The GRA coefficients of the sensory characteristics were found as 0.736 and 0.719 WBS, 0,606 and 0.540 tenderness, 0.659 and 0.657 juiciness, 0.511 and 0.564 flavour, 0.464 and 0.521 acceptability, and 0.557 and 0.571 NCBS respectively in the Awassi and Red Karaman. We can say that the CRC coefficients are very close to each other in each sensory characteristics, and accordingly, the preferability degrees of the breeds are close to each other in terms of the sensory characteristics. Esenbuga *et al*. (2009) stated that there was no difference between the Awassi and Red Karaman breeds in terms of tenderness, juiciness, flavour, acceptability, NCBS and WBS sensory characteristics. Esenbuga *et al*. (2001) stated that there was no difference between the Awassi, Red Karaman, Tushin and Awassi×Tushin breeds in terms of tenderness, juiciness, flavour, acceptability, NCBS and WBS sensory characteristics.

It was observed that the relation degrees of the LD, TB and SMD muscles were close to each other and high in terms of the WBS characteristic as per the CRC coefficients, and it can be said that those three muscles are highly preferred in terms of the WBS characteristic. While the SMD (0.750) muscle was found very high in terms of tenderness, the LD (0.484) and TB (0.504) muscles had low values; this indicates that the SMD muscle is more preferable in terms of tenderness. The same situation is valid for the juiciness characteristic and the most preferred muscles were found as 0.743 SMD, 0.633 TB and 0.595 LD for the juiciness characteristic, respectively. No obvious difference was found between the preferability degrees of the muscles in terms of the flavour and Acceptability characteristics. The muscles most preferred in terms of the NCBS characteristic were found as 0.630 LD, 0.594 TB and 0.466 SMD, respectively. Esenbuga *et al.* (2009) no found any statistically significant difference in the Flavour characteristic while they found statistically important differences between the LD, ST and TB muscles in terms of tenderness, juiciness, acceptability, NCBS and WBS sensory characteristics. Esenbuga *et al*. (2001) stated that there was no statistically important difference between the LD and SM muscles in terms of tenderness, juiciness, flavour, acceptability, NCBS and WBS sensory characteristics.

Conclusion: It was found that the most preferred muscles were LD, SMD and TB respectively when the preferability status of the muscles according to the GRG relation coefficient was researched in the Red Karaman breed. Moreover, WBS, juiciness, NCBS, flavour, tenderness and acceptability were respectively found as the most important sensory characteristics determining the preferability of the mutton in the Red Karaman breed.

It was determined upon the investigation of the muscle preferability status according to the GRG relation coefficient that the most preferred muscles were SMD, LD and TB respectively in the Awassi breed. Besides, WBS, juiciness, tenderness, NCBS, flavour and Acceptability were respectively found as the most important sensory characteristics determining the preferability of the mutton in the Awassi breed.

It was seen that the most preferred muscle was SMD in the Awassi breed, LD in the Red Karaman breed, and the least preferred muscle in both breeds was LD. WBS and Juiciness were found as the most important sensory characteristics for the preferability of the mutton in both breeds.

It was observed that the relation degrees of the LD, TB and SMD muscles were close to each other and high in terms of the WBS characteristic as per the CRC coefficients, and it can be said that those three muscles are highly preferred in terms of the WBS characteristic. On the other hand, No obvious difference was found between the preferability degrees of the muscles in terms of the flavour and acceptability characteristics.

When both breeds were evaluated together, it was found that there was no important difference between the muscles according to the grey relation coefficient, but the most preferred muscles were SMD (GRG=0.607), LD (GRG=0.589) and TB (GRG=0.578), respectively. In the sensory analysis made within this study, it was determined that the most important factors distinguishing the preferability status of the mutton were WBS (GRG=0.729), juiciness (GRG=0.658), tenderness (GRG=0.581), NCBS (GRG=562), flavour (GRG=0.532) and acceptability (GRG=486), respectively.

The grey relational analysis can be suggested as an appropriate method that can be used in individual comparisons of the examined animals or selection studies such as selecting the parents of the future generations in populations especially with less sample sizes within the field of animal breeding and improvement.

Conflıct of Interest: We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. All the authors/co-authors declare that they have no conflict of interest.

REFERENCES

Baş, M. and Z. Çakmak (2012). Determination of the Financial Failure in Businesses with the Grey Relational Analysis and Logistic Regression Analysis and an Implementation. Anadolu Uni. J. Social Sci. 12(3): 63-82.

Deng, J. J. (1982). Control problems of GreySystems. Systems and Control Letters, 1(5): 288-294.

Esenbuga, N., M. Macit, M. Karaoglu, V Aksakal, M.I. Aksu, M.A. Yoruk, and M. Gul (2009). Effect of

breed on fattening performance, slaughter and meat quality characteristics of Awassi and Morkaraman lambs. Livestock Sci.123: 255-260.

Esenbuga, N., M. Yanar, and H. Dayıoglu (2001). Physical, chemical and organoleptic properties of ram lamb carcasses from four fat-tailed genotypes. Small Rum. Res. 39:99-105.

Grajales-Lagunes A., C. Rivera-Bautista, M. Ruiz-Cabrer, R. Gonzales-Garcia, J. Ramirez-Telles, and M. Abud-Archila (2012). Effect of lactic acid on the meat quality properties and the taste of pork Serratus ventralis muscle. Agr. Food Sci. 21: 171-181.

Hsu C. J. and C.Y. Huang (2006). Comparison and Assessment of Improved Grey Relation Analysis for Software Development Effort Estimation. Proceedings of 3rd IEEE International Conference on Management of Innovation and Technology, 21-23 June, Singapore.

Huuskonen, A., E. Joki-Tokola, M. Honkavaara, L. Tuomisto and R. Kauppinen (2010). Meat quality and fatty acid profile of M.longissimus dorsi of growing bulls under insulated, uninsulated and outdoor housing conditions. Agr. Food Sci. 19: 214-222.

Keskin, S., A. Kor, and S. Karaca (2012). Evaluation of sensory characteristics of sheep and goat meat by Procrustes Analysis. Czech J. Anim. Sci., 57(11): 516–521.

Santos-Silva J. and A. Vaz Portugal (2001). The effect of weight on carcass and meat quality of Serra da Estrela and Merino Branco lambs fattened with dehydrated lucerne. Anim. Res. 50: 289-298.

Wu, C.H. (2007): On the Application of Grey Relational Analysis and RIDIT Analysis to Likert Scale Surveys. Proceedings of International Mathematical Forum, 2(14): 675-687.

Xia, X., Y. Lu, T. Ma and L. Chen (2012). Identification Method for Evolution of Time Series with Poor Information Using Grey System Theory. Mechanical Eng. Res. 2(1): 71-75.

Xiaojun, C., H. Xianxi, and T. Xuerui (2010). Polar Grey Relational Analysis on Sexual Satisfaction and Hemoglobin in Essantial Hypertensive Patients. J. Grey System, 1: 89-96.

Xuerui, T., D. Julong, and C. Xiaojun (2007). Generalized Grey Relational Grade and Grey Relational Order Test. Proceeding of 2007 IEEE International Grey Systems and Inteligent Services, Nanjing, China, 3928-3931.