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The Effects of Aging Period and Muscle Type on the Textural Quality Characteristics of Mutton

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Abstract: In this research, the effects of aging on some of the textural quality characteristics of *Longissimus dorsi* (LD) and *Semimembranosus* (SM) muscles from mutton carcasses were evaluated. The results showed that the aging process significantly ($P<0.01$) improved panel tenderness, number of chews and fragmentation index values. Also, the aging period significantly ($P<0.05$) affected some Instron parameters. While the muscle type did not significantly influence these parameters, the hardness and chewiness values measured by the Instron were significantly ($P<0.01$) affected by muscle type, and the values were 4.84, 6.06 kg and 1.78, 2.40 kg for *LD* and *SM* muscles respectively. In conclusion, the application of the aging process for mutton carcasses from ewes could be beneficial for the meat industry by increasing the merchandising quality of this kind of carcasses.

Key Words: Carcass Aging, Textural Quality, Mutton.

Olgunlaştırma Periyodu ve Kas Çeşidinin Koyun Karkaslarının Tekstürel Kalite Özelliklerine Etkisi

Özet: Bu çalışmada, koyun karkaslarından elde edilen *Longissimus dorsi* (LD) ve *Semimembranosus* (SM) kaslarının bazı tekstürel kalite özellikleri üzerine olgunlaştırma sürelerinin etkileri değerlendirilmiştir. Araştırma sonuçları, olgunlaştırma işleminin panel gevreklik skoru, çiğneme sayısı ve fragmentasyon indeksi değerlerini önemli derecede ($P<0.01$) iyileştirdiğini göstermiştir. Ayrıca, olgunlaştırma periyodu bazı instron tekstür parametrelerini de önemli derecede ($P<0.05$) etkilemiştir. Bu parametreler üzerine, kas çeşidi önemli derecede bir etki yapmazken, instronla ölçülen sertlik ve çiğneme değerleri çok önemli derecede ($P<0.01$) kas çeşitlerinden etkilenmiş ve bu değerler, sırasıyla LD için 4.84, 6.06 kg, SM için de 1.78, 2.40 kg olarak belirlenmiştir. Sonuç olarak, nispeten yaşlı koyunlardan elde edilen karkaslara uygulanan olgunlaştırma işleminin, bu tür karkasların ticari değeri ve kalitesinin artırılmasında faydalı olduğu ve bu nedenle et sanayicilerine tavsiye edilebileceği anlaşılmıştır.

Anahtar Sözcükler: Karkas Olgunlaştırma, Tekstürel Kalite, Koyun.

Introduction

Sheep breeding is a popular traditional activity in Middle Eastern or Mediterranean countries, contributing a great amount to the national income. In most of these countries, local sheep breeds are predominant, and generally grow slowly. Additionally, the farmers in these countries prefer to utilize pastures to produce heavier carcasses for more income (1). For these reasons, sheep are slaughtered at an advanced chronological age and/or increased physiological maturity, which is associated with toughness of ovine carcasses. Reddy et al. (2) noted that the most accepted method of tenderization for meat is aging, but this process is not commonly practiced in this area of the world. As the living standards of these countries increase, people are becoming more demanding of high quality (more tender) mutton. However, there is little research on mutton with respect to quality alterations influenced by different factors (3-5).

This research was conducted to determine the influence of the aging process on some of the textural and organoleptic quality characteristics of mutton *Longissimus dorsi* (LD) and *Semimembranosus* (SM) muscles assessed by Instron WBS and Compression Test, as well as sensory evaluation and fragmentation index.

Materials and Methods

Six mature Western crossbred (Black x White Face) ewes (average 5 years old) raised in a research farm were grazed in pasture and 0.8 kg of concentrate were offered

daily. The ewes were conventionally slaughtered, pelted, eviscerated and split into halves, placed into a cooler (1±1°C), and used as samples. The LD and SM muscles were excised, and then muscle portions were cut perpendicularly to the muscle fiber into 0.5 inch chops. Seven chops per animal were placed into unsealed polyethylene bags for conditioning for a selected time period (one or seven days postmortem), and the tempered samples were used for the following analysis.

Fragmentation index values were determined by the procedure described by Davis et al. (6). Mechanical assessment of muscle tenderness was carried out employing two different tests (Warner-Bratzler Shear force determination and compression tests) by using an Instron Universal Testing Machine (Instron 1000, Canton Maine). The following parameters were then measured from the force deformation curves of the Warner-Bratzler shear force determination test: **a)** Initial yield force (first major inflection on force-distance curve in kg), **b)** Peak force (maximum force recorded on the force-distance curve in kg), **c)** Initial yield distance (the distance from the first registering of force to the initial force point in cm), **d)** Final yield distance (the distance from the first registering of force to the point where the sample finally yielded in cm), **e)** Work done (total amount of work needed to shear the core: determined by using the total area under the curve with a polar planimeter and expressed in mm^2), and **f)** Peak force minus initial yield force value (7).

The parameters obtained from the Instron compression measurements were as follows: **a)** Peak force 1 (kg)(Hardness), **b)** Peak force 2 (kg), **c)** Peak force distance 1 (cm), **d)** Peak force distance 2 (cm), **e)** Work done 1 (Area of the first peak, A_1 in mm^2), **f)** Work done 2 (Area of the second peak, A_2 in mm^2, **g)** Cohesiveness (The ratio of the area A_2/A_1), **h)** Chewiness (Peak force 1 (kg) x cohesiveness) (8).

For sensory panel evaluation, the mutton chops were cooked using a water bath as described by Bouton et al. (9), and the sensory evaluation was accomplished by six trained sensory panelists (average meat evaluation experience was six years). Panelists independently evaluated each sample for degree of tenderness, juiciness, amount of residue remaining after chewing, and the number of chews before breaking up of the meat tissue. Scores excluding number of chews were obtained using a nine point hedonic scale (10). The number of chews was determined by counting the chews prior to swallowing. The pH of the muscles was also measured at 1 and 7 days postmortem as described by Ockerman (10). The data obtained in the study was analyzed statistically by ANOVA. Two-way analysis of variance was used to determine the effects of time of aging on muscles, and significant differences between mean values were analyzed using Duncan's multiple range test.

Results and Discussion

pH values: The average pH values of LD and SM muscles measured at 1 and 7 days of the aging period were 6.38, 6.35 and 5.49, 5.66 respectively. The pH difference between the muscles was not statistically significant when the aging period had a significant ($P<0.05$) influence on pH decline.

Sensory Evaluation, Fragmentation Index: Least square means with standard errors of scores for panel tenderness, juiciness, residue after chewing, number of chews, fragmentation index score and cooking loss values are presented in Table 1. The aging process significantly ($P<0.01$) improved panel tenderness, number of chews scores and fragmentation index values. The tenderness, number of chewing and fragmentation index scores for the aging treatments of and seven days were 3.62, 6.05 and 55.29, 40.45 and 506.00, 318.20 respectively. Also, cooking loss was significantly ($P<0.05$) lowered by the aging period. Although the juiciness of samples aged seven days was lower than that of samples aged one day, there was no significant ($P>0.05$) difference. The residue after chewing was not influenced significantly ($P>0.05$) by the aging treatment. Similar tenderness improvements with aging for other types of carcasses have also been reported by several researchers (11-14).

The influence of muscle type on the tenderness score was statistically significant ($P<0.05$), and the LD muscle was more tender than the SM. These findings support the results of Wenham et al. (15), Taylor and Marshall (16) and Mederios et al. (17).

Instron Warner-Bratzler Test: The parameters measured in this study for the Instron Warner-Bratzler test are presented in Table 2. The aging process significantly ($P<0.05$) affected peak force, initial yield force and work done values. The peak force, initial yield force and work done values for the samples aged one or seven days were 8.66, 5.34 kg; 7.30, 4.94 kg; and 7.28,

Table 1. LSM[1] and SE[2] for the effects of aging period and muscles on sensory properties, fragmentation index and cooking loss of mutton tissue.

	Parameters					
	Tenderness[5]	Juiciness[6]	RA AfterChewing[7]	Frag. Index [8]	Number of Chews[9]	Cooking Loss %
Muscle Type[3]						
LD	5.63±0.54	4.75±0.32	5.10±0.42	398.33±14.00	42.85±3.84	25.54±0.93
SM	4.05±0.50	4.62±0.30	6.00±0.39	425.90±14.00	52.89±3.55	31.16±0.93
Significance	*	NS	NS	NS	NS	**
Aging Period[4]						
1-Day	3.62±0.46	4.75±0.28	6.08±0.36	506.00(14.00	55.29±3.31	29.92±1.02
7-Day	6.05±0.59	4.60±0.35	5.02±0.46	318.20(14.00	40.45±4.18	26.78±0.86
Significance	**	NS	NS	**	**	*
Aging Periods x Muscle Type						
1-DxLD	4.16(0.66	4.56±0.39	6.08±0.51	505.30(19.80	51.08±4.68	27.74±1.40
7-DxLD	7.09±0.86	5.01±0.51	4.11±0.67	291.30±19.80	34.62±6.10	23.35±1.22
1-DxSM	3.08±0.65	5.00±0.34	6.08±0.52	506.60±19.80	59.50±4.68	32.10±1.40
7-DxSM	5.02±0.75	4.20±0.45	5.93±0.59	345.10±19.80	46.29±5.33	30.21±1.22
Significance	NS	NS	NS	NS	NS	NS

[1] Least square means; [2] Standard error; [3] LD: *Longissimus dorsi*; SM: Semimembranosus; [4]1-Day: 1st day of aging, 7-Day: 7th day of aging; [5]Scored on a scale of 1-9 [extremely tough (1) to extremely tender (9)]; [6]Scored on a scale of 1-9 [extremely dry (1) to extremely juicy (9)] [7]RA: Residue after Chewing scored on a scale of 1-9 [from a few (1) to a lot (9)]; [8]Frag.: Fragmentation, as fragmentation index increases meat becomes less tender; [9]Number of chews was determined by panel members before meat sample was broken up and swallowed; *: P<0.05,**: P<0.01, NS: Non-Significant.

Table 2. LSM[1] and SE[2] for the effects of aging period and muscles on Instron Warner Bratzler shear test of mutton tissue.

	Parameters					
	Peak F-I F[5] (kg)	Work Done (mm^2)	Initial Y F[6] (kg)	Initial Y D[7] (cm)	Peak F[8] (kg)	Final Y D[9] (cm)
Muscle Type[3]						
LD	0.65±0.42	5.29±0.57	5.24±0.74	1.08±0.04	6.03±0.82	2.82±0.13
SM	1.11±0.46	6.21±0.59	7.00±0.80	1.09±0.05	7.97±0.89	2.46±0.14
Significance	NS	NS	S	NS	*	NS
Aging Period[4]						
1-Day	1.26±0.39	7.28±0.54	7.30±0.69	1.05±0.04	8.66±0.77	2.74±0.12
7-Day	0.50±0.02	4.21±0.64	4.94±0.88	1.13±0.05	5.34±0.97	2.54±0.15
Significance	NS	**	*	NS	*	NS
Aging Periods x Muscle Type						
1-DxLD	1.02±0.50	7.05±0.80	6.07±0.98	1.05±0.06	7.35±1.09	2.92±0.17
7-DxLD	0.28±0.01	3.52±0.82	4.41±1.12	1.15±0.06	4.70±1.24	2.73±0.20
1-DxSM	1.49±0.50	7.51±0.72	8.53±0.98	1.05±0.06	9.96±1.09	2.56±0.17
7-DxSM	0.72±0.07	4.90±0.94	5.47±1.28	1.14±0.08	5.97±1.42	2.36±0.23
Significance	NS	NS	NS	NS	NS	NS

[1] Least square means; [2] Standard error; [3] LD = Longissimus dorsi SM = Semimembranosus; [4] 1-Day: 1st day of aging, 7-Day: 7th day of aging; Peak F-I F[5] : Peak Force Minus Initial Yield Force; Initial Y F[6]: Yield Force; Initial Y D[7]: Yield Distance; Peak F8: Force; Final Y D9: Yield Distance; *: P<0.05, **: P<0.01, NS: Non-Significant.

4.21 mm^2 respectively. The results were in accordance with the findings of Bouton et al. (9) and Reddy et al. (2), who reported the maximum tenderness of mutton in 7 days of aging. Previous studies showed that some variation, even within the same muscle, could occur due to the effects of aging or muscle with respect to toughness up to 4 kg (18). From the initial yield force and peak force value determined in this research, it could be concluded that aging of the samples may have weakened the myofibrils and connective tissue network,

and a decrease in these values has been reported by Davey and Dickson (19) and Fukazawa et al. (20).

Muscle type had a significant (P<0.05) effect on the peak force value (Table 2). The LD muscle had lower peak force (6.03 vs 7.97 kg) than the SM muscle. Other parameters were not significantly (P>0.05) affected by muscle type. Similar results have been also reported by Solomon (21), who noted that the Instron peak force of the LD muscle was significantly lower than that of the SM.

Instron Compression Test: The results of the compression test are shown in Table 3. Although the hardness, work done 1 and peak force 2 values of samples aged seven days were lower than those of the control, the differences between treatments were not great enough to be significant (P>0.05). The hardness, work done 1 and peak force 2 values for aging tneatments of one and seven days were 5.56, 5.34 kg; 5.61, 4.95 kg; 4.42 and 3.81 kg respectively. The values again were in the direction of increased tenderness for mutton tissue aged for seven days, but the lack of significance might be ascribed to the sample size of six used in this research.

Hardness and chewiness were highly significantly (P<0.01) influenced by muscle type (Table 3). Hardness and chewiness values for LD and SM groups were 4.84, 6.06 kg and 1.78, 2.40 kg respectively. The results demonstrated that the SM muscle was harder than the LD muscle, and the SM muscle required a higher number of chews than the LD to break up the muscle tissue.

The results of this study suggest that the aging process had a significant effect on some textural quality properties of mutton, such as tenderness score and number of chews. Additionally, the fragmentation index was significantly influenced by the aging treatment. However, only muscle type had a significant effect on the panel tenderness score. The peak force, initial yield force and work done values measured by the Instron WBS were significantly improved by aging, while only muscle type had a significant effect on the peak force value. In conclusion, the aging process could positively affect the tenderness and some quality characteristics of mutton from old ewes, and this would be beneficial for the meat processors and consumers who prefer more tender meat.

Table 3. LSM[1] and SE[2] for the effects of aging period and muscles on Instron compression test of mutton tissue.

	Parameters							
	Work Done 1 (mm^2)	Work Done 2 (mm^2)	Cohesiveness	Chewiness (kg)	Peak F[5]. 1 Hardness	Peak F[5]. 2 (kg)	Distance1 (cm)	Distance2 (cm)
Muscle Type[3]								
LD	5.15±0.322	1.66±0.27	0.35±0.02	1.78±0.13	4.84±0.27	3.76±0.43	0.87±0.03	0.53±0.02
SM	5.41±0.36	2.52±0.30	0.39±0.02	2.40±0.14	6.06±0.36	4.47±0.48	0.86±0.03	0.54±0.02
Significance	NS	NS	NS	**	**	NS	NS	NS
Aging Period[4]								
1-Day	5.61±0.35	1.81±0.28	0.36±0.02	2.08±0.13	5.56±0.29	4.42±0.46	0.90±0.03	0.53±0.02
7-Day	4.95±0.37	2.37±0.30	0.38±0.02	2.10±0.14	5.34±0.31	3.81±0.44	0.83±0.03	0.54±0.02
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Aging Periods x Muscle Type								
1-DxLD	5.77±0.46	1.48±0.38	0.32±0.02	1.83±0.18	5.19±0.38	3.87±0.62	0.92±0.04	0.54±0.03
7-DxLD	4.53±0.47	1.83±0.38	0.38±0.02	1.73±0.18	4.48±0.39	3.65±0.63	0.83±0.04	0.53±0.03
1-DxSM	5.45±0.53	2.13±0.44	0.40±0.03	2.32(0.21	5.92±0.44	4.97±0.72	0.88±0.04	0.53±0.03
7-DxSM	5.37±0.54	2.91±0.44	0.38±0.03	2.47±0.21	6.20±0.45	3.97±0.72	0.83±0.04	0.55±0.03
Significance	NS	NS	NS	NS	NS	NS	NS	NS

[1] Least square means; [2] Standard error; [3] LD: Longissimus dorsi SM: Semimembranosus; [4] 1-Day: 1st day of aging, 7-Day: 7th day of aging; Work done 1: Area of first peak, A_1; Work done 2: Area of second peak, A_2 ; Cohesiveness: Ratio of area A_1/A_2; [5]Peak Force (kg; *: P<0.05, **: P<0.01, NS: Non-Significant,

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