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SHORT COMMUNICATION

Effects of Electrical Stunning and Electrical Stimulation on Kivircik Carcass Quality [1] [2]

Tolga KAHRAMAN * Özer ERGUN *

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* Istanbul University, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology, 34320, Avcılar, Istanbul - TURKEY

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Summary

A total of 20 Kivircik breed lambs were used in two experiments to study the effects of electrical stunning (EB) and the electrical stimulation (ES) on meat quality. At slaughter, lambs were divided into two groups as control and EB group and slaughtered by applying Halal method. After splitting the carcasses at vertebral line, medium voltage electrical stimulation (MVES) or low voltage electrical stimulation (LVES) was applied to the right half carcasses. The left half carcasses were used as control. Meat quality was evaluated on *M. longissimus dorsi* by examining pH at 1, 3, 6, 24 h; shear force (SF), water holding capacity (WHC) and colour (L*, a*, b*) at 1 and 7 days of post-slaughter period. As a result, the lowest SF, pH and WHC were demonstrated from the ES applied samples in comparison with control samples. Only a* values of colour parameters were affected at 7 days of post-slaughter period. In conclusion, lamb meat quality can be markedly improved by using the combination of EB and ES.

Keywords: *Electrical stimulation, Meat quality, Kivircik breed lambs*

Elektrikle Bayıltma ve Elektrik Stimülasyonunun Kıvırcık Karkas Kalitesi Üzerine Etkileri

Özet

Toplam 20 baş Kıvırcık ırkı kuzu, elektrikle bayıltma (EB) ve elektrikle stimülasyon (ES) uygulamalarının et kalitesi üzerine etkilerini incelemek amacıyla kullanıldı. Kuzular, kesim sırasında kontrol ve EB grubu olmak üzere iki gruba ayrıldı ve tüm kuzular İslami usul ile kesildi. Karkaslar ikiye ayrıldıktan sonra sağ yarımlara orta ve düşük voltaj olmak üzere ES uygulaması yapıldı. Sol taraf ise araştırmada kontrol grubunu oluşturdu. Et kalitesinin belirlenmesi amacıyla *longissimus dorsi* kasında 1., 3., 6., 24. saatlerde pH, 1. ve 7. günlerde gerilme kuvveti, su tutma kapasitesi ve renk değerleri incelendi. Sonuç olarak, ES kaslarda hızlı pH düşüşü ile birlikte gerilme kuvveti değerlerini kontrol gruplarına nazaran azaltmış ve etlerin su tutma kapasitesi değerlerini önemli ölçüde düşürmüştür. Renk değerleri içinde, sadece 7. günde kırmızılık artmıştır. Sonuçta EB ile birlikte ES uygulanan koyun kaslarının et kalitesi değerleri belirgin şekilde gelişmiştir.

Anahtar sözcükler: *Elektrikle stimülasyon, Et kalitesi, Kıvırcık ırkı kuzu*

INTRODUCTION

Meat quality can be influenced by pre-slaughter and post-slaughter factors. Pre-slaughter factors include breed, sex, age of slaughter, feed, handling, type of muscle, carcass composition and environment [1]. Post-slaughter factors involve the biochemical dynamics of the early postmortem period such as ageing, enzymes used, mechanical tenderization and electrical stimulation (ES) [2].

ES involves transmitting an electrical current through the carcasses of freshly slaughtered animals [3]. This electrical current leads muscle contraction and accelerates postmortem glycolysis by the depletion of the energy reserves in the muscle, thereby decreasing the risk of cold shortening [4]. The ability of ES to enhance the quality of meat has been observed in several studies [3,5-7]. However, some reports conclude that there has been no improvement in the meat quality by applying ES [8,9]. In the last three decades, ES has received considerable attention for improving the

İletişim (Correspondence)
☎ +90 212 4737070/17152
✉ mail: tolgakah@istanbul.edu.tr

meat quality with its positive effects on tenderness, colour and palatability in different food animals. Although, there have been few studies on lamb.

In Turkey, lamb meat is a significant protein source and is accepted alternative to the beef. A 20.5% of total meat production is supplied from the lamb meat in the country [10]. Among the Turkish lamb breed, Kivircik that raised in the Trakya, southern and eastern provinces of Marmara Region of Turkey, is met the important on lamb meat production demand. The objective of this investigation study is to evaluate the influence of the effects of electrical stunning (EB) and ES on meat quality of Turkish native lamb, Kivircik.

MATERIAL and METHODS

Stunning and Stimulation Procedures

A total of 20 Kivircik breed lambs (8 month old male) weighting between 38 to 42 kg from same farm were used as material. Lambs were transported to the slaughterhouse from farm within 15 min for 1 day prior to slaughter. During this period, they were provided with ad libitum water and kept without feed for 24 h before slaughter. At slaughter, lambs were divided into two groups. The first group lambs were stunned electrically (ESL, n=10) at 220-250 V, 1.0-1.3 A for 1-3 sec, stunning tongs applied on both sides of the head. The second group lambs were slaughtered without stunning (USL, n=10). All the lambs were slaughtered by applying Halal Method. Following exsanquination and evisceration, all the carcasses were halved by splitting through the vertebral column approximately in 45 min post-slaughter period. Both lamb groups were divided into three groups according to ES. Half carcasses in the first group were stimulated with medium voltage (MVES; 100 V, 100 Hz for 120 s) and second group were stimulated with low voltage (LVES; 50 V, 100 Hz for 120 s). ES was applied to the right sides of each carcasses and the corresponding left carcasses were used as controls since no electrical stimulation was applied to them (no electrical stimulation, NES) *(Table 1)*. After electrical stimulation, all the half carcasses were maintained at 0 to 4°C air flow 1 to 1.5 ms^{-2}.

Table 1. *The allocation of carcass sides to the electrical stunning and the electrical stimulation treatments*

Tablo 1. *Elektrikle bayıltma ve elektrikle stimülasyon uygulamalarına göre karkasların dağılımı*

Stunning Application	ES Application		
	MVES	LVES	NES
ESL	5 right carcasses	5 right carcasses	10 left carcasses
USL	5 right carcasses	5 right carcasses	10 left carcasses

ESL, Electrically Stunned Lambs; USL, Non-Electrically Stunned Lambs; ES, Electrical Stimulation; MVES, Medium Voltage Electrical Stimulation (100 V 100 Hz for 1 sn on 1 sn off for during 120 sec.); LVES, Low Voltage Electrical Stimulation (50 V 100 Hz for 1 sn on 1 sn off for during 120 sec.); NES, No Electrical Stimulation

Sampling and Measurements

At about 1 h post-slaughter period, *longissimus dorsi* muscles of the carcasses were excised at the line of 12th rib. The effects of EB and ES on postmortem glycolysis was monitored by measuring pH values in triplicate at 1, 3, 6 and 24 h with a penetrating electrode adapted to a portable Hanna HI 8314 elektro pH meter.

At 24 h post-slaughter period, the carcasses were transferred to the cutting room and the *M. longissimus dorsi* between 11th and 12th thoracal vertebrae from the each carcass were removed and cut into six equal portions. Three of the samples were vacuum packaged in Cryovac barrier bags then held in the same cold room and were stored for 6 days prior to the evaluating the shear force (SF), water holding capacity (WHC) and colour (L*, a*, b*). The other portions were transported to the laboratory for initial measurements.

SF values were measured using an Instron Texture Analyzer Machine model 1140 equipped with a Warner Bratzler device. Water holding capacity (WHC) of meat, the percentage of free water, was measured by a filter paper press method [11]. Colour as L* lightness, a* redness, b* yellowness values was measured using Minolta CR 400 colorimeter [12].

Statistical Analysis

The paired t-test and analysis of variance with Duncan's multiple range tests were performed to the differences among the groups. The data of the meat quality variables were analyszed by the SPSS [13], using the analysis of variance (ANOVA). To asses the different voltage applications were analyzed according to a split-plot design using the General Linear Model (GLM) procedure.

RESULTS

Results of the effect of EB and ES on meat parameters at 1 and 7 days of post-slaughter period are prensented in *Table 2*.

Table 2. *Effect of the electrical stunning and the electrical stimulation on quality parameters of Kivircik carcasses*
Table 2. *Elektrikle bayıltma ve elektrikle stimülasyon uygulamalarının Kıvırcık karkaslarının kalitesi üzerine etkisi*

Parameters		Time	Electrical Stunning and/or Electrical Stimulation Treatments					
			Electrically Stunned Group (ESL)			Non- Electrically Stunned Group (USL)		
			Medium Voltage Electrical Stimulation (MVES) (n=5)	Low Voltage Electrical Stimulation (LVES) (n=5)	Control (NES) (n=10)	Medium Voltage Electrical Stimulation (MVES) (n=5)	Low Voltage Electrical Stimulation (LVES) (n=5)	Control (NES) (n=10)
pH		1 h	6.08±0.03 ^{bB}	6.16±0.02 ^{bB}	6.43±0.03 ^{aB}	6.33±0.02 ^{bA}	6.40±0.01 ^{bA}	6.56±0.02 ^{aA}
		3 h	5.80±0.03 ^{bB}	5.86±0.02 ^{bB}	6.18±0.04 ^{aB}	5.98±0.02 ^{bA}	6.00±0.06 ^{bA}	6.27±0.02 ^{aA}
		6 h	5.64±0.02 ^{bB}	5.64±0.02 ^{bB}	5.84±0.02 ^{aB}	5.76±0.04 ^{bA}	5.82±0.02 ^{bA}	5.95±0.02 ^{aA}
		24 h	5.46±0.02 ^{bB}	5.53±0.02 ^{bB}	5.61±0.02 ^{aB}	5.55±0.02 ^{cA}	5.62±0.02 ^{bcA}	5.66±0.02 ^{aA}
Shear Force (SF) (Newton)		24 h	2536.33±52.9 ^{cB}	2799.56±51.0 ^{b}	3159.10±53.6 ^{a}	2738.82±60.5 ^{cA}	2875.29±27.7 ^{b}	3389.30±136.2 ^{a}
		7 day	973.58±52.7 ^{cB}	1654.96±91.7 ^{b}	2001.50±90.1 ^{a}	1209.26±68.2 ^{cA}	1582.87±29.4 ^{b}	1984.89±101.9 ^{a}
Water Holding Capacity (WHC) (%)		24 h	38.40±0.24 ^{aA}	35.60±0.24 ^{b}	35.20±0.37 ^{c}	37.40±0.24 ^{aB}	35.20±0.37 ^{b}	34.60±0.24 ^{c}
		7 day	43.60±0.40 ^{aA}	43.20±0.37 ^{a}	42.20±0.66 ^{b}	42.20±0.37 ^{aB}	41.40±0.24 ^{a}	42.40±0.24 ^{b}
Colour	L*	24 h	53.51±2.46	53.76±0.71	51.22±1.68	56.06±1.36	52.85±0.39	51.32±0.30
		7 day	48.34±0.92	47.55±1.93	45.06±0.40	47.84±0.43	47.84±0.95	46.39±0.33
	a*	24 h	14.05±0.38	12.37±0.73	12.12±0.38	13.63±0.49	12.90±0.17	12.64±0.57
		7 day	11.59±0.43 ^{a}	11.06±0.41 ^{a}	9.50±0.67 ^{b}	11.55±0.49	10.30±0.12	10.46±0.67
	b*	24 h	12.86±0.47	12.35±0.59	13.55±0.50	13.06±0.46	13.09±0.67	13.12±0.02
		7 day	11.95±0.43	11.68±0.56	11.48±0.55	12.63±1.28	12.17±0.52	11.74±0.79

n, Number of half carcasses
a, b, c : Values in the same row with different superscripts are significantly different between stimulation treatments (P<0.05)
A, B: Values with different superscripts are significantly different between the stunning treatments (P<0.05)
n, Yarım Karkas Sayısı
a, b, c : Aynı satırda farklı harf taşıyan gruplar arasındaki farklılıklar, istatistik bakımından önemlidir(P<0.05)
A, B: Farklı harf taşıyan bayıltma grupları arasındaki farklılıklar, istatistik bakımından önemlidir (P<0.05)

DISCUSSION

Analysis of pH in *longissimus dorsi* muscle of lamb carcasses showed a significant correlation (P<0.05) between ES and NES groups. However no significant differences were found between LVES and MVES (P>0.05). ES resulted more rapid pH decline. Similar results in pH have been reported by Polidori et al.[5] and Morton et al.[6]. On the other hand, effect of EB on pH was significant (P<0.01). The pH values of ESL were lower than USL. Similar to those was found by Vergara et al.[12]. These results suggested that the ES treatment caused an acceleration of glycolysis and subsequent early rigor mortis development. And also EB may prevent to increase in pH at postmortem that caused depletion of the muscle glycogen stores antemortem, resulting in a decreased lactic acid production at post-slaughter period.

ES applied carcasses were more tender than NES at 1 and 7 days of post-slaughter period (P<0.001). Also significant differences were found between LVES and MVES (P<0.05). These findings were supported by other studies in lamb carcasses [6] and beef carcasses [14]. The differences in pH may be the cause of the lower values of SF in meat of ES applied samples, due to decreased activity of calpain. MVES induced more degradation of physical dimensions of muscles due to the higher voltage. In ESL groups, SF results were lower than USL. But significant differences in tenderness were found only at MVES (P<0.05). Our findings were slightly similar to the study obtained by Vergara and Gallego [15].

WHC was significantly greater for stimulated carcasses (P<0.005). And the present study also revealed that MVES were more effective than the LVES only at 1 days of post-slaughter period (P<0.05). These results support the theory that ES significantly increased drip loss. Similar to those was found by Janz et al.[7]. In contrast, McKenna et al.[8] reported that ES didn't affect the water holding capacity in beef muscles. In this study the authors supported that moisture loss accompanied the physical disruption and reduced water holding capacity. Between EB

groups, WHC values were significant only in MVES ($P<0.05$). Similar results in lamb carcasses were reported by Vergara and Gallego [15]. It was concluded that EB application without ES combination did not affect the WHC values.

Initial colour parameters were not affected by ES ($P>0.05$), but at 7 days of post-slaughter period, significant differences were found in a* values among the groups ($P<0.01$). Between EB groups, values of L, a, b were not affected ($P>0.05$). Our findings in this study showed similarity with the report of Eikelenboom et al.[3]. In contrary, McKenna et al.[8] has found no differences between the ES and NES. The result of this study may be explained that ES reduce the colour stability, as defined by the rate of metmyglobin accumulation in the surface layer of meat [16].

As a result, the lowest SF, pH and WHC were demonstrated from the ES applied samples in comparison with control samples. Only a* values of colour parameters were affected at 7 days of post-slaughter period. In conclusion, lamb meat quality can be markedly improved by using the combination of EB and ES.

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