COMBINATION EFFECTS OF LOW VOLTAGE ELECTRICAL STIMULATION AND POSTMORTEM TEMPERATURE CONDITIONING ON MEAT QUALITY OF IRANIAN FAT TAILED SHEEP

M. Abbasvali [1]*, S.S. Shekarforoush [1], M. Aminlari [2]
[1]Department of Food Hygiene and public health, School of Veterinary Medicine, Shiraz University, Shiraz 71345-1731, Iran
[2]Department of Biochemistry, School of Veterinary Medicine, Shiraz University, Shiraz 71345-1731, Iran
*Corresponding author (phone: +98 711 2286950; fax: +98 711 2286940; e-mail: maryamevali@yahoo.com)

Abstract

Electrical stimulation (ES) has been reported to improve meat quality. In this study, the combination effects of low voltage electrical stimulation with variable voltage/duration and early postmortem (PM) rigor temperature (4 °C and 25 °C until 4 h postmortem) on the quality of 24 male Iranian fat tailed sheep carcasses were evaluated, including the rate of pH and temperature decline, free amino acid (FAA) content and myofibrillar fragmentation index (MFI) of *longissimus dorsi* muscle. Each carcass was subjected to one of the eight treatments. In two experimental groups (T1 and T2) no stimulation were subjected (controls) and early PM temperature conditioning 4 °C and 25 °C until 4 h PM, were respectively used. Furthermore, Six groups (T3, T4, T5, T6, T7 and T8) were stimulated five min PM with variable voltages (100 and 150V), duration (30 and 60 sec) and fixed frequency (50 Hz), and rigor temperature (4 °C and 25 °C until 4 h PM). Each carcass was compared to its corresponding non-ES control group. Carcass pH and temperature were measured at 1, 3, 6, 12 and 24 h PM. The effects of ES on proteolysis and tenderness were also recorded by measuring FAA content at 1, 7 and 14 days PM and MFI at 1,3,5,7 and 14 days PM. The results showed that ES combined with temperature conditioning accelerated the glycolytic process resulting in a significant fall in pH ($P < 0.05$) during PM. There were significant differences in pH decline between treatment groups ($P < 0.05$). No differences in muscle temperature decline were observed between groups with similar rigor temperature and different ES treatments compare to the control groups ($P > 0.05$), indicating no effect of ES on carcass cooling rate. The results of FAA content and MFI showed that proteolysis and tenderness were significantly improved by ES during PM ($P < 0.05$). The best improvement in tenderness, meat quality and glycolytic rate acceleration were seen in T8 in which the carcass treated accordingly.

Key words: **Electrical stimulation, fat tailed sheep, free amino acid, MFI**

I. INTRODUCTION

Extensive studies have been completed to clarify the mechanisms responsible for meat quality during postmortem (PM) storage. It is generally accepted that PM glycolytic rate is a major parameter influencing meat tenderness (Rhee & Kim, 2001). Tenderness improvement can be achieved by employing various PM treatments including ageing, mechanical tenderization methods and electrical stimulation (Devine, Wells, Cook, & Payne, 2001; King, Voges, Hale, Waldron, Taylor, & Savell, 2004; Strydom, Frylinck, & Smith, 2005). Postmortem carcass electrical stimulation (ES) has been shown to improve the tenderness of meat, possibly by preventing cold shortening, accelerating proteolysis, and disrupting muscle fiber structures (Seideman, & Cross, 1982).

Lamb meat is a significant protein source throughout the world especially in the developing countries. Fat tailed sheep is one of the most important food animals in Iran with a very popular meat. Information on PM glycolysis and tenderness in Iranian fat tailed sheep carcass is very limited.

The objectives of this study were to investigate the effects of low voltage electrical stimulation and early PM temperature conditioning on meat quality in Iranian fat tailed sheep carcasses.

II. MATERIALS AND METHODS

A. Animals and experimental design

A total of 24 male Iranian fat tailed sheep were used for this experiment. In the first experimental group (T1) carcasses without any ES were chilled at 4 ºC for 14 days PM, as control for treatment groups of T3, T4, T6 and T7. Carcasses in the second group (T2) without any ES, were kept at 25 °C for 4 h, and then placed in a chiller at 4 °C for 14 days. They were used as control group for treatment groups of T5 and T8. Five minutes after bleeding, carcasses in the treatment groups of T3, T4, T6 and T7 were stimulated with 100v 30s, 100v 60s, 150v 30s and 150v 60s with fixed frequency of 50 Hz, respectively and were chilled at 4 °C for 14 days. Carcasses in the treatment groups of T5 and T8 were stimulated 100v 60s and 150v 60s, respectively and were kept at 25 °C for 4 h, and then placed in a chiller at 4 °C for 14 days. Samples were collected from both treated and control groups from M. *longissimus dorsi* at different times PM.

B. pH and temperature measurement

pH and temperature of *longissimus dorsi muscle* were recorded at 1, 3, 6, 12 and 24 h PM using a pH/temperature meter (Testo 205, USA). Measurements were recorded at the location of 7th/8th rib interface with a similar depth.

C. Free amino acid analysis

Free amino acid (FAA) was measured at 1, 7 and 14 days PM according to the OPA spectrophotometric assay (Church, Swaisgood, Porter, & Catignani, 1983; Fadda, Chambon, Champomier-Verges, Talon, & Vignolo, 2008). Results were expressed as absorbance at 340 nm.

D. MFI measurement

MFI was determined at 1, 3, 5, 7 and 14 days PM using procedure of Culler, Parrish, Smith, and Cross (1978).

E. Statistical analyses

The results were evaluated by one-way analysis of variance technique and Duncan's multiple-range test at the significance level of 0.05. All statistical analyses were performed by SPSS software, version 11.

III. Results and discussion

There were significant differences in muscle temperature at 1, 3, 6 and 12h PM between treatment groups with different rigor temperature, but no differences were found beyond 12h until 24h PM (Figure 1). No significant differences in temperature were found between groups with similar rigor temperature and different ES treatments at any of the measured times PM. Although, the ES had no significant effect on the carcass cooling rate, the pH values of *longissimus dorsi* muscle were affected by ES and PM time. ES accelerated the pH decline resulting in the pH of stimulated muscle become significantly lower than the non stimulated muscle up to 24 h PM (Figure 2). After a relatively fast fall within the first 6 h, the mean pH values for all the carcasses underwent a slow decline until 24 h PM. These findings are in accordance with those of Polidori, Lee, Kauffman, and Marsh (1999). Li, Chen, Xu, Huang, Hu, & Zhou (2006) reported that ES led to a fast fall in pH within the first 3 h in beef. Variation might be due to different low voltage electrical stimulation conditions, e.g. duration of stimulation, application step, and electrical condition. There were also differences in the rate of pH decline between the treatment groups with different rigor temperature. Rigor temperature had effect on the rate of pH decline. Similar results reported by Rhee et al., (2001). Electrical stimulation with higher voltage/duration (150v 60s) in combination with 25 °C rigor temperature showed the fastest pH drop. These results suggest that both ES and temperature conditioning until 4h PM used in this study accelerated PM pH decline.

The variations in the concentration of FAA resulting from the effects of different treatments were shown in Table 1. The amounts of FAA released during storage at 4 °C increased significantly during 14 days. These results are in accordance with those of Feidt, Petit, Bruas-Reignier and Brun-Bellut, (1996) who observed that storage of beef at 4 °C during 14 days PM increases the amount of FAA. When compared to the control groups, increase in amino acids concentration was significantly higher in stimulated samples, these data being in agreement with previous work (Mikami, Nagao, Sekikawa, Miura, & Hongo, 1994). The highest amino acid concentration was observed in the group eight, indicating that higher voltage of ES and duration of stimulation had higher effect on the release of soluble amino acids. ES may contribute to the improvement of meat flavor or taste, by increasing the release of FAA during PM conditioning of meat (Sekikawa, Seno, Shimada, Fukushima, & Mikami, 1999). Nishimura (2002) also reported that storage of beef at low temperature improves flavor by increasing the FAA and peptides.

The MFI was significantly higher in groups with different ES treatments compared to the non-ES. MFI has been used as an indicator of PM proteolysis in meat (Lametsch, Knudsen, Ertbjerg, Oksbjerg, & Therkildsen, 2007). Martin, Hopkins, Gardner, and Thompson (2006) showed that stimulated carcasses as opposed to non stimulated carcasses resulted in a higher MFI. In the present study there were significant differences between the five times of ageing and MFI (Figure3). Martin et al. (2006) demonstrated that the MFI value increased with ageing. Their findings are in accordance with the outcomes of this study. The differences in MFI may therefore, account for differences in the rate of PM tenderization of meat (Nagaraj, Anilakumar, & Santhanam 2005).

IV. Conclusion

Combination of higher voltage/duration of ES (150v, 60s) and 25 °C conditioning until 4 h PM showed greater effects to hasten glycolysis, accelerated pH decline, enhanced degradation of myofibrillar proteins, increased the release of FAA and improved tenderness of Iranian fat tailed sheep carcass.

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Table1. Effects of electrical stimulation and rigor temperature (4 ℃ and 25 °C until 4 h postmortem) on the release of free amino acids of the samples in Iranian fat tailed sheep during postmortem storage at 4 ℃.

	Free amino acid (OD at 340 nm) in treatment groups							
Days	T1	T2	T3	T4	T5	T6	T7	T8
1	0.43 ± 0.01 a	0.46 ± 0.00 b	0.48 ± 0.00 bc	0.49 ± 0.00 c	0.55 ± 0.01 d	0.54 ± 0.01 d	0.56 ± 0.01 d	0.56 ± 0.01 d
7	0.52 ± 0.01 a	0.60 ± 0.00 b	0.62 ± 0.00 bc	0.63 ± 0.01 cd	0.64 ± 0.01 cd	0.66 ± 0.01 d	0.72 ± 0.02 e	0.78 ± 0.01 f
14	0.76 ± 0.03 a	0.85 ± 0.01 b	0.89 ± 0.01 c	0.94 ± 0.00 d	0.96 ± 0.01 de	0.98 ± 0.00 de	0.98 ± 0.00 e	0.99 ± 0.00 e

T1: No electrical stimulation, chilled at 4 ℃; T2: No electrical stimulation, kept at 25 °C for 4 h, and then at 4 ℃; T3: stimulated with 100V, 30 sec., chilled at 4 ℃; T4: stimulated with 100V, 60 sec., chilled at 4 °C; T5: stimulated with 100V, 60 sec., kept at 25 °C for 4 h, and then at 4 ℃; T6: stimulated with 150V, 30 sec., chilled at 4 °C; T7: stimulated with 150V, 60 sec., chilled at 4 °C; T8: stimulated with 150V, 60 sec., kept at 25 °C for 4 h, and then at 4 °C. Different letters in each rows indicate statistically significant differences ($p<0.05$).

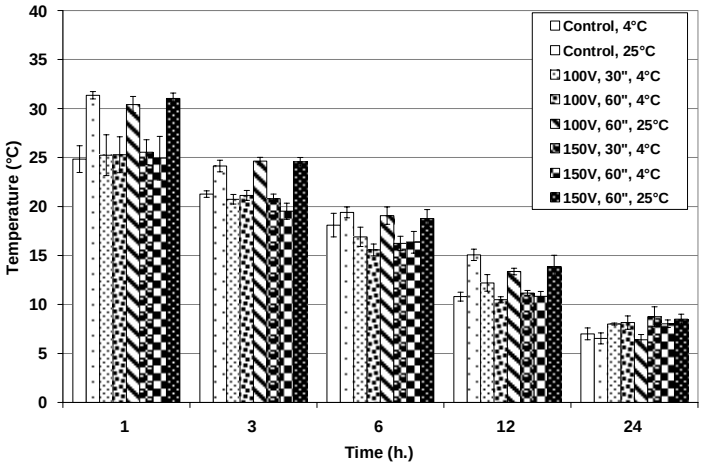

Figure1. Effects of electrical stimulation and rigor temperature (4 °C and 25 °C until 4 h of postmortem) on the muscle temperature of Iranian fat tailed sheep during postmortem storage at 4 °C.

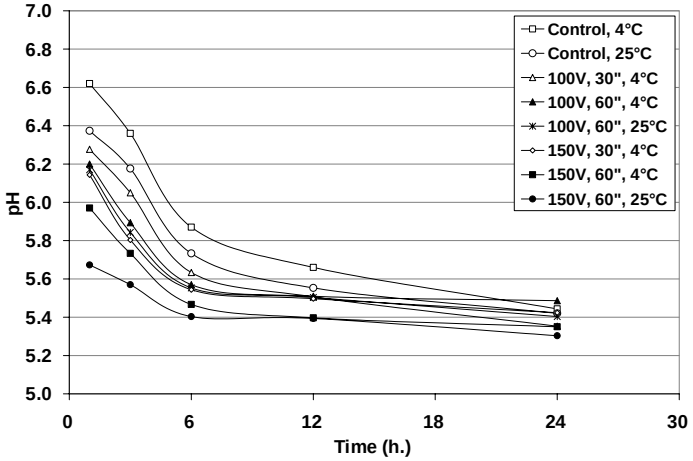

Figure 2. Effects of electrical stimulation and rigor temperature (4 °C and 25 °C until 4 h postmortem) on the muscle pH of Iranian fat tailed sheep during postmortem storage at 4 °C.

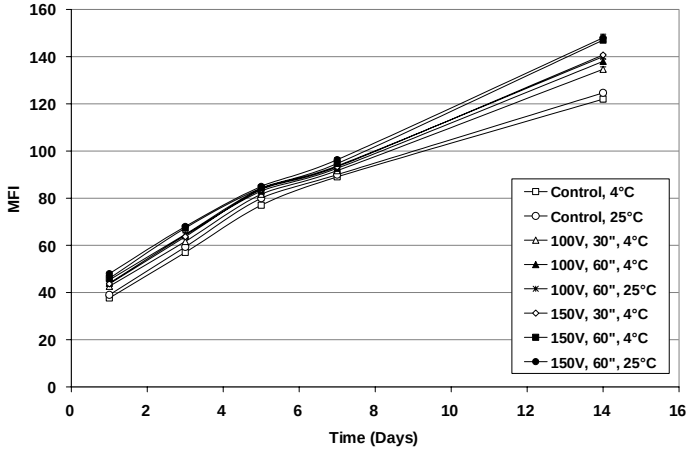

Figure 3. Effects of electrical stimulation and rigor temperature (4 °C and 25 °C until 4 h postmortem) on the myofibrillar fragmentation index (MFI) on the muscle of Iranian fat tailed sheep during postmortem storage at 4 °C.