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The Influence of Electrical Stimulation and Muscle Types on Some Biochemical Properties of Mutton

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Introduction

Sheep are one of the important source of meat produced by livestock in many countries. Despite this fact, there is little research about the effects of electrical stimulation (ES) on biochemical and histological changes of tough mutton which makes it undesirable for retailing. The objective of this research was to determine temperature and pH values of the LD and SM muscles of mutton with and without ES at various time intervals postmortem in order to monitor postmortem glycolysis and histological parameters.

Material and Methods

A total of 6 mature (3-5 years old) crossbred ewes were conventionally slaughtered, eviscerated and split within 30-45 minutes post-exsanguination. One sides of each carcasses was subjected to electrical stimulation (ES) with the parameters of 350 V for 45 sec using a total of 15 impulses (1.5 sec on and 1.5 sec off). Following the ES, carcass halves were washed and placed in the chill cooler (approximately 1±1°C for 7 days). The temperature and pH of the muscles were measured at pre and post-ES as well as 1, 2, 3, 4, 5, 6, 24 h, and 7 days postmortem. Sarcomere length was determined by following the procedure described by Herring et al. (1965) and fiber diameter with the procedure used by Parrett (1972). The data obtained was subjected to statistical analysis using SAS (1986).

Results and Discussion

pH: Results concerning pH decline are plotted in Fig. 1. Although there were no significant effect ($P>0.05$) of ES on the pH values prior to and immediately after stimulation, ES had a marked influence on muscle postmortem glycolysis during 7 days of storage. Stimulated LD and SM muscles had significantly ($P<0.05$) lower pH than control groups at 1, 2, 3, 4, 5, 6, 24 hours and 7 days postmortem (Fig. 1). This result was in agreement with the various researchers reporting that ES accelerates the rate of postmortem glycolysis in muscle tissue of different species (Whiting et al., 1981; Gariepy et al., 1992). Activation of glycolytic enzymes by ES might be one of the causative factors and this was supported by Rashid (1983) who reported that glycolytic enzymes such as, aldolase, phosphofructokinase, glyceraldehyde 3-phosphate dehydrogenase and pyruvatekinase might be bonding to actin filaments in stimulated muscles and increase the rate of glycolysis. How fast the postmortem pH drops to 6 is considered to be an indication of the effectiveness of ES (Whiting et al., 1981). Both stimulated LD and SM muscles pH's dropped to 6 within 2 hours post-stimulation while approximately 4 hours was required to diminish the pH to 6 in the non-ES muscles. This result is also in agreement with the findings of Whiting et al., (1981) that ES tremendously reduce the time required to drop to a pH to 6. Bendal et al., (1976) stated that the time to reach pH 6 was 1.5, 2.0, and 8.8, 8.3 h for stimulated (300 V) beef LD and SM, and control LD and SM muscles respectively. In lamb, Whiting et al., (1981) found that pH of stimulated (280 V) LD muscle reached a pH of 6 in 2 hrs postmortem while the control groups required 10-13 hrs. The maximum pH decline rate immediately after and 1 hr post-stimulation of the LD and SM muscles resulted in a pH decline of 0.17 and 0.18 while it took 4 - 5 hr post-stimulation for the control muscles. Also, during the time period between 1 and 3 hours post-stimulation, the pH decline rates of the stimulated muscles were significantly ($P<0.05$) higher than those of the non-ES muscles, and the pH decline rate gradually decreased with postmortem time.

Temperature: Fig. 2 shows that ES did not have a significant ($P<0.05$) effect on the muscle temperature decline. This result was not unexpected since other researchers have also reported that ES on the muscle temperature decline was not affectived (Solomon and Lynch, 1991; Gariepy et al., 1992). The type of muscle had a significant influence on the temperature decline (Fig. 2). Temperatures of the SM were significantly ($P<0.05$) higher than that of the LD muscle at 1, 2, 3, 4, 5rs h post-stimulation. But at 24 and 168 hrs (7 days) post-stimulation, the temperature differences between SM and LD muscles were not statistically significant ($P>0.05$). The back-fat thickness of the mutton carcasses used in this study average 1.2 mm, and because of the thin subcutaneous fat of the carcasses, the LD muscle may not be well protected from cold temperatures as was the case for the SM. As a consequence, the LD muscle cooled faster than the SM which is relatively well insulated with fat and it's large size protected it from the cold. These results agreed with the findings of Shorthose et al., (1986), Romita et al. (1987) who reported the temperature decline in SM muscle was slower than that of the LD muscle. The temperature decline rate was the greatest in the time period between immediately after stimulation and 1 h post-stimulation (Fig. 2), and temperature decline rate decreased as post-stimulation time proceeded. At 1 and 2 hrs post-stimulation, the temperature decline rates in the LD muscles were significantly ($P<0.05$) higher than those of the SM muscle. Again, these results are due to lack of insulating effect of the subcutaneous fat over the LD muscle. Similar results were also reported by Smith et al., (1974) an indicated that a high rate of temperature decline was found in lamb LD (with <2.5 mm subcutaneous fat) at the first and second hrs postmortem.

Sarcomere length and diameter: Sarcomere length of the stimulated and non-stimulated mutton tissue were 1.85 and 1.84 mm respectively. ES did not have a significant effect on sarcomere length. The result also revealed that the carcasses used in this study were not exposed to cold shortening. Bendall (1972) defined the conditions causing cold shortening (muscle temperature below 11 °C before the pH was below 6.2). Based on this criterion, cold shortening should not be present in these animals. In fact, sarcomere length, pH and temperature values supports this conclusion. Also, the reports in literature are controversial concerning the influence of ES on sarcomere length. For example, some researchers postulating that tenderness improvement with ES was due to the prevention of cold shortening. Davey, (1976) found that the sarcomere length of ES muscle was significantly longer than that of non-ES muscle. However, some studies revealed that no difference existed in shortening between ES and non-ES muscles (Smulders and Eikelenboom, 1986; Gariepy et al., 1992). In this study, the muscle type also did not significantly ($P>0.05$) influence the sarcomere length values which measured 1.79 and 1.80 mm for LD and SM muscles respectively. Shorthose and Harris (1990) also reported that sarcomere length of stimulated LD and SM muscle were not significantly ($P>0.05$) different in bovine tissue.

In this research, the fiber diameter were also not affected by any of the treatments which were 62.09 and 61.34 μm for stimulated and control groups respectively. Similar results were also reported by Reddy et al. (1991) that the muscle fiber diameter of ES and control groups were not significantly ($P>0.05$) different. The SM muscle (63.58 μm) had a larger fiber diameter than the LD (59.85 μm) muscle, but the difference was not statistically significant ($P>0.05$). However, there was a significant ($P<0.05$) negative relation

(r= -0.32) between sarcomere length and sarcomere diameter. Similar types of relationships (r = -0.82, and r = -0.39) have also been reported by Herring et al., (1965) and Cross et al., (1972) respectively.

Conclusion

The results of this research showed that postmortem glycolysis rate in LD and SM muscles of mutton were significantly accelerated by ES. While temperature decline rate was not affected by ES, the difference between the muscles was significant. The sarcomere length and sarcomere diameter measurements were not altered by the treatments used in this research. Therefore, it could be concluded that ES changed physical properties and might be helpful in altering eating characteristics of mature mutton.

References

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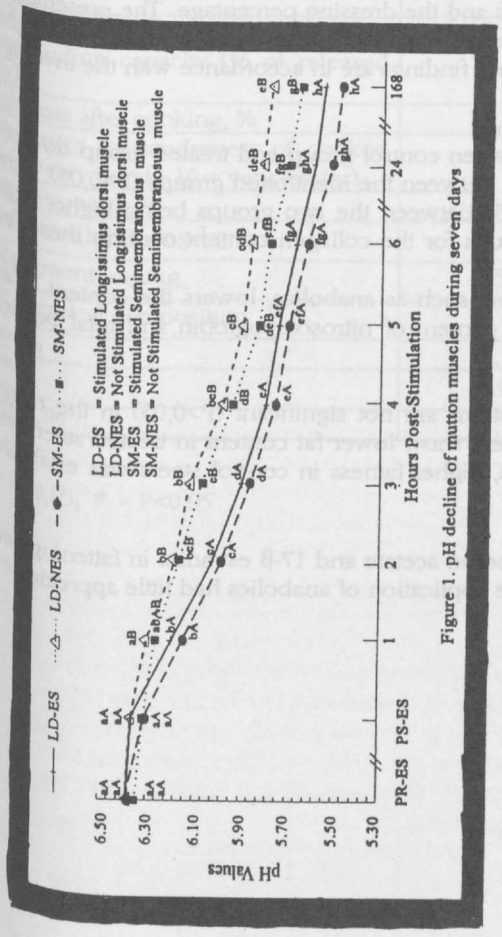

Figure 1. pH decline of mutton muscles during seven days

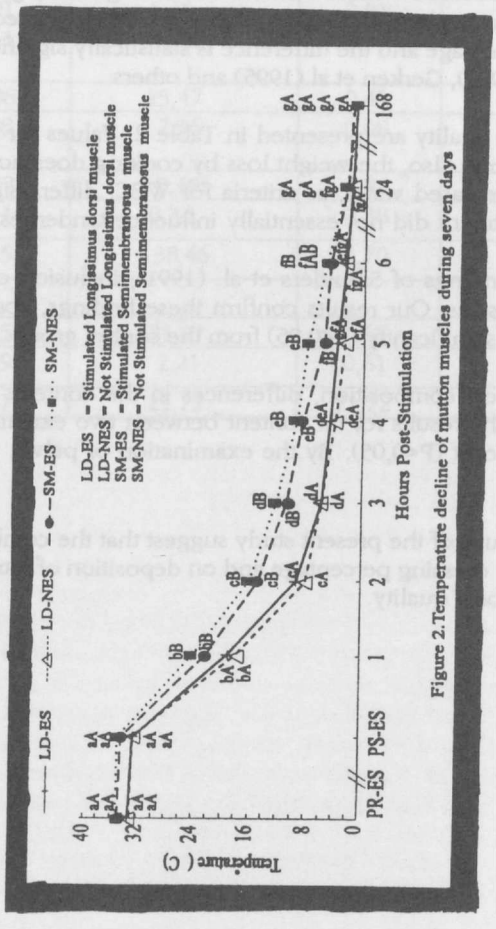

Figure 2. Temperature decline of mutton muscles during seven days