Biochemical and Quality Characteristics of Ovine Muscle as Affected by Electrical Stimulation, Hot Boning, and Mode of Chilling

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Story in Brief

The combined effects of electrical stimulation and carcass holding temperature were evaluated on some biochemical and quality characteristics of intact and hot-boned ovine muscles. Twenty-four lamb sides were randomly assigned to 4 treatments. Electrical stimulation was performed within 15 minutes postmortem (350 V with 10 Hz) for 4 minutes. Electrically stimulated and slowly chilled (5 hr at 14 ± 2°C) sides exhibited significantly more rapid pH decline in the longissimus dorsi (LD) muscle, less cold shortening in the semitendinosus (ST) muscle, and greater tenderness in both LD and ST muscles than sides at 2°C. None of the treatments had an effect on the cooking loss in ST and LD muscles. Lean color and solubility of the different protein fractions, as well as, the swelling factor of the stroma protein of LD muscles did not change during a 4-day retail display treatment.

Introduction

It is generally accepted that cold shortening will cause muscle toughness when lamb and beef carcasses are chilled or frozen in the prerigor state. Cold shortening can be minimized by delaying the exposure of the carcass to cold temperatures until the muscle pH has reached a value of 6.0 and approximately 50 percent of the adenosine triphosphate (ATP) has been depleted.

However, this problem can be resolved by electrical stimulation of the carcass which ensures a fast drop in pH and a rapid depletion of muscle ATP. Even though electrical stimulation has been adopted, little information is available regarding its combined effect with the mode of chilling. Some of the biochemical-biophysical changes which take place may be related to meat quality. Hence, the aim of this study was to investigate the combined effect of electrical stimulation and slow chilling of lamb carcasses at 14 ± 2°C for 5 hours postmortem on some biochemical and quality characteristics of specific ovine muscles.

Materials and Methods

Twelve Suffolk wether lambs were slaughtered, skinned, eviscerated, and divided into sides. Twenty-four sides were randomly assigned to 4 treatments. Accordingly, a total of 12 sides, selected at random, were electrically stimulated

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(ES) while 12 sides were kept as unstimulated (US) or control. In each case, 6 sides, at random, received a rapid chilling (RC) treatment and the other 6 sides were subjected to slow chilling. The sides were electrically stimulated (350 volts, 10 pulse per second, and 20% duty cycle) within 15 minutes postmortem using a direct current with a square wave pulse for 4 minutes. The electrical current was applied by two wires each terminated with a clamp. One clamp was attached to the neck region at the level of the 5th and 6th cervical vertebrae as the negative charge and the other clamp was attached to the achilles tendon as the positive charge to complete the circuit.

Two muscles, namely the LD and ST muscles were used to study the changes in some biochemical and quality characteristics. The ST muscle was hot-boned from both the ES and US sides immediately after electrical stimulation and the LD muscles remained attached to the skeleton. The extent of cold shortening and cooking loss on hot-boned ST muscle were determined at 24-hour postmortem. Postmorten pH and temperature changes were monitored (at 0, 2, 4, 6, 8, and 24 hr postmortem) on intact LD muscles. Thereafter, fresh samples were taken to measure the lean color during a 4-day retail display using a Hunterlab Tristimulus Colorimeter and recorded as L, a, and b values as well as a/b color ratio, solubility of different protein fractions (sarcoplasmic, myofibrillar, acid soluble, and insoluble stromal proteins as well as the swelling factors of the stroma protein), and cooking loss. The shear force value for LD and ST muscles was determined at 48 hr postmortem.

Results and Discussion

Stimulated sides, whether rapid or slow chilled, had a significantly lower pH than the respective control muscles at 2, 4, 6 and 8 hours postmortem (Figure 1). Muscle from electrically stimulated slow chilled sides (ES + SC) experienced a greater pH decline than the rapid chilled (ES + RC) sides. On the other hand, postmortem pH decline in the unstimulated sides whether slow or rapid chilled (US + SC) and (US + RC) was almost identical. However, there was no significant variation in temperature decline between the stimulated and control sides for any given chilling procedures (rapid or slow). Hence, differences in the rate of pH decline for the LD muscle between stimulated and control cannot be ascribed to difference in carcass temperature decline. Activation of glycolytic enzymes by electrical stimulation may be one of the causative factors accounting for the rapid pH fall in electrically stimulated carcasses. Whether or not electrical stimulation increased the glycolytic enzymes activities per se in muscle has not been completely defined.

The muscle from stimulated and slow chilled sides (ES + SC) had significantly less ($P<0.05$) shortening than the control groups (Table 1). However, there was no significant difference ($P>0.05$) in the percent of shortening of the ST strips from electrically stimulated sides, whether they were rapid or slow chilled. On the other hand, ST strips from control sides shortened significantly more when rapidly chilled than when slow chilled. The present study shows that ES reduced the percent of muscle shortening. Rapid depletion of the energy rich phosphate compounds (adenosine triphosphate and phosphocreatine), which determine the degree of muscle fiber shortening during chilling or freezing of carcasses may be attribued to ES.

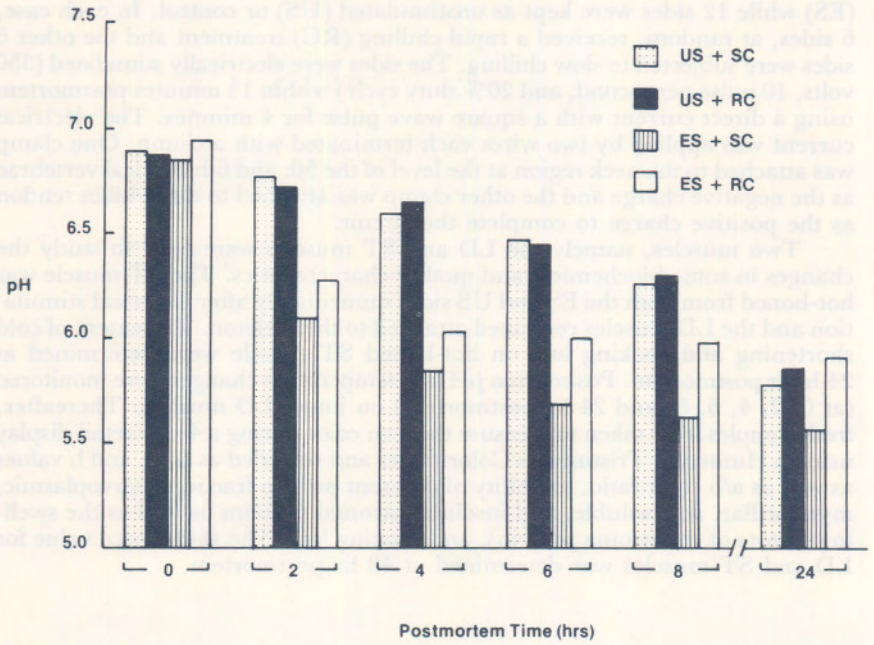

Figure 1.Postmortem pH decline for LD muscle as affected by electrical stimulation and mode of chilling.

Table 1. Muscle shortening (%), shear force (Kg) and cooking loss (%) values for ST and LD muscles as affected by electrical stimulation and mode of chilling.

Treatment[1]	Muscle shortening (%)[2]	Shear force, (kg)[3]		Cooking loss (%)[2]	
	ST	ST	LD	ST	LD
ES + SC	10.6[a]	5.0[a]	4.1[a]	13.2[a]	19.7[a]
ES + RC	13.1[ab]	5.6[b]	4.0[a]	16.1[a]	18.9[a]
US + SC	15.7[b]	6.3[c]	5.1[b]	16.3[a]	19.7[a]
US + RC	19.6[c]	6.4[c]	5.4[b]	14.3[a]	19.0[a]
S.D. of Adj. Mean	0.99	0.13	0.13	0.52	0.50

[1]See Table 1 for treatment.
[2]Each muscle shortening and cooking loss value is averaged from 12 samples in both ST and LD muscles
[3]Each shear force value is averaged from 48 samples for ST muscle and from 72 samples for LD muscles.
Means within a column followed by different letters are significantly different ($P < 0.05$).

Electrical stimulation significantly ($P<0.05$) decreased shear force value as compared to those from the control regardless of the postmortem chilling procedure for both ST and LD muscles (Table 1). Most investigators have shown that electrical stimulation of carcasses produced a tenderizing effect on the musculature. With respect to the cooking loss, the data indicated no significant differences ($P>0.05$) in either ST and LS muscles as affected by electrical stimulation and chilling temperature (Table 1).

The lean color measurements using Hunterlab L, a and b values and the a/b color ratio of LD loin chops at 24-hour intervals for 4 days were not significantly different among all treatments. Most of the studies, based on panel evaluation, have found the meat from stimulated carcasses generally to be brighter with a more youthful lean color than that from unstimulated carcasses. However, several workers agreed that electrical stimulation did not improve lean color.

Neither electrical stimulation nor the chilling rate had any significant effect ($P>0.05$) on the solubility of the sarcoplasmic protein fraction as compared to the control. No change was noted in the solubility of myofibrillar proteins extracted sequentially with unbuffered 0.3 M NaCl solution followed by 0.6 M KI in 0.1 M phosphate buffer. Acid-soluble protein (freshly synthesized collagen) and acid-insoluble stromal proteins (biologically mature collagen and some elastin) were not significantly affected by electrical stimulation and carcass chilling. The swelling factor which is used as an indicator of changes in the extent of crosslinkage of collagen was also not affected by electrical stimulation. As a matter of fact, very limited information is available on the influence of electrical stimulation of carcasses on the connective tissue (extracellular) proteins, and more information is needed.