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Effects of high voltage electrical stimulation on the rate of pH decline, meat quality and colour stability in chilled beef carcasses

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Abstract

Fifty beef carcasses were used to determine the effects of High Voltage Electrical Stimulation (HVES, 800 Volts) on pH and meat quality. Meat from *M. longissimus dorsi* was examined for pH and temperature at 1, 2, 5, 10 and 24 hours, while tenderness and colour were examined seven days after slaughter. HVES decreased the pH of the meat and accelerated rigor mortis ($P<0.05$). HVES improved tenderness and colour compared with the control group across the ageing period at 4°C. It is suggested that HVES had positive effects on tenderness and colour. (*Bangl. vet*. 2013. Vol. 30, No. 1, 33 – 38)

Introduction

Brazil is one of the largest beef producers in the world, with millions of cattle. The beef is used within the country and around the world (Smith, 1976).

Colour and taste affect consumers' preferences. These can be improved by chemical and physical methods, such as high-voltage electrical stimulation (HVES), applied to beef carcasses immediately after slaughter. In commercial beef abattoirs, rapid chilling of beef carcasses to around 2°C pre-rigor has been widely used to improve the microbiological condition and decrease evaporative loss. According to Locker and Hagyard (1963), lowering the carcass temperature below 10°C sooner than 10 hours postmortem will cause cold shortening. It is critical to avoid cold shortening, and electrical stimulation has been proven as effective in preventing the toughening effect of cold shortening (Geesink *et al*., 2001; Hwang *et al*., 2003; Li *et al*., 2006; Warris, 2001).

Notwithstanding, electrical stimulation can cause a decline in postmortem pH (accelerating the rate of glycolysis). For the safety of the operators, low-voltage electrical stimulation (LVES; voltage <100 V) is frequently used in many countries instead of high-voltage (> 100 V). However, LVES has been reported to be less effective than HVES for meat quality (Hwang and Thompson, 2001; Janz *et al*., 2001).

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The objective of the present study was to determine the effects of HVES combined with pre-rigor rapid chilling on carcass pH, temperature, weight decline and beef quality.

Materials and Methods

Animals

Fifty Holstein bulls approximately 18 months old, weighing 500 ± 30 kg, fed on green pasture grass were transported to Promissao Commercial Modern Beef Abattoir, Brazil. After fasting for 12 hours with only water available, the animals were randomly distributed into two treatment groups (n = 25). All bulls were killed on the same day and stunned using a captive bolt before exsanguination. In the first group, as a control, carcasses were conventionally chilled (air temperature 1□C and humidity above 95%) without electrical stimulation. Carcasses in the second group were electrically stimulated for 25 s immediately after bleeding, using the High Voltage Stimulator (voltage 800 V and current 2.5 A) and conventionally chilled. After chilling the carcass weight was recorded.

Carcass pH, temperature and meat quality measurements

The pH and temperature of the carcass were monitored using a portable pH meter and needle-tipped thermometer (GPRT1400AN Digital pH/mV/Thermometer, Greisinger®, Australia) about 1 hour (i.e. before chilling) and 2, 5, 10 and 24 hours post-mortem. For each measurement, the pH probe and thermometer were inserted into the carcasses at a depth of 4 mm into the *M. longissimus* muscle). Meat quality was assessed on the back (*M. longissimus*) and thigh (*M. semimembranosus*) muscles. At 24 hours postmortem, the muscles were removed and vacuum packed then held in the same cold room (10-15□C) for seven days prior to evaluating the colour. A nine-member trained sensory panel scored the colour, wetness and tenderness acceptability on the basis of the ten-point hedonic rating scale (Kerth *et al*., 1999).

Statistical analyses

The effects of HVES and pre-rigor rapid chilling on the carcass pH, temperature decline and evaporative loss were evaluated by one-way analysis of the variance, where carcass pH, temperature decline and evaporative loss were used as dependent variables and variables of treatment group as an independent variable. Different treatment groups were compared using Duncan`s multiple-range test, at the significance level of 0.05. All statistical analyses were performed by SAS9.2 (SAS Institute Cary, North Carolina, 2010).

Results and Discussions

Compared with the meat control group (Fig. 1, 2), HVES reduced the postmortem pH and temperature of beef carcass ($P<0.05$). Differences between the groups at 0, 3, 5, 10 and 24 hour were statistically significant ($P<0.05$). Similarly, many studies report that

electrical stimulation accelerates glycolysis and causes a rapid pH decrease (Kim *et al*., 2013; Polidori *et al*., 1999; Soares *et al*., 1995). Morton *et al*. (1999) applied HVES (1130 V, 1.8-2 A) for 90 second to sheep carcasses. In the present study too, better results (800 V, 25 sec) were obtained in the muscles with lower electricity usage.

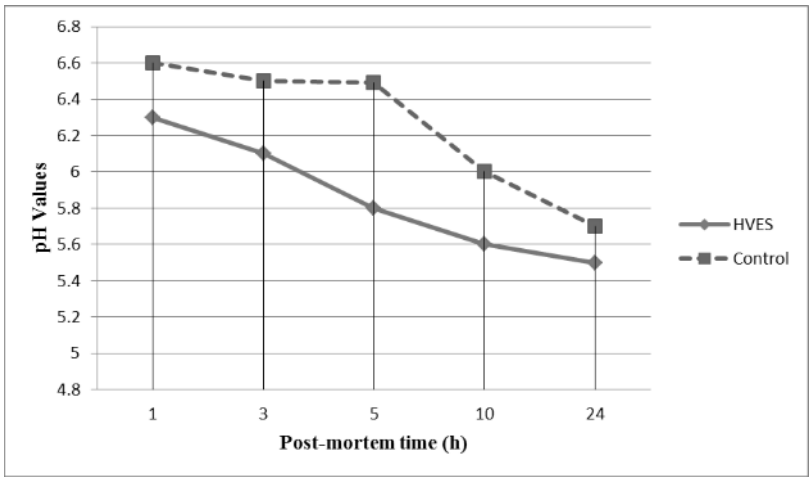

Fig. 1. pH decline of beef carcasses within two groups

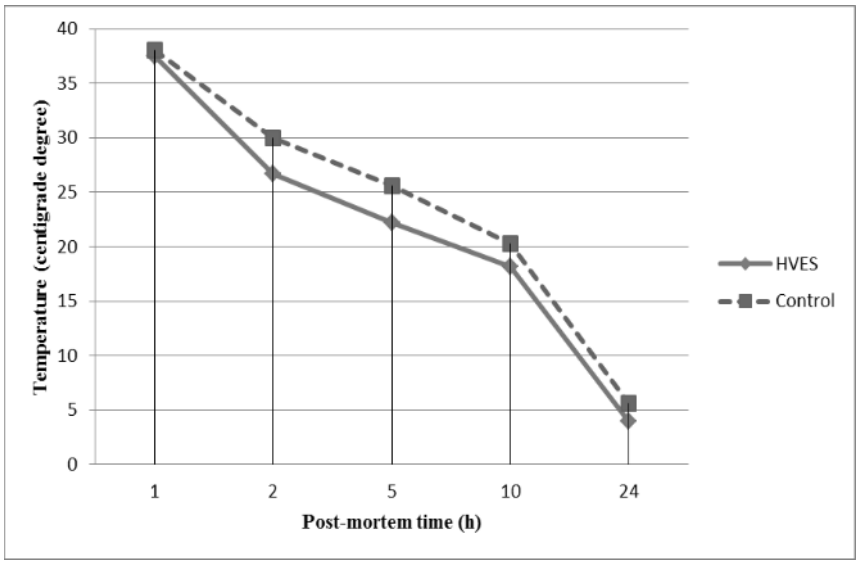

Fig. 2. Temperature decline of beef carcasses within two groups

In a study conducted by Taylor and Martoccia (1995) on pork meat, HVES caused a 0.3 unit decrease in pH 45 minutes postmortem.

Studies on bovine and buffalo muscle extensibility indicated that rigor mortis occurs at pH 5.9 (Bendall, 1973). Applying these criteria to our study, rigor mortis occurred after five hours. There is no report in literature on Brazil Holstein meat HVES and the

present results are comparable to the majority of those for bovine, buffalo, deer and ovine carcasses (Marsh *et al*, 1987; Harris and Shorthose, 1988; Carballo *et al*, 1988; Smulders *et al*, 1989; Soares *et al*, 1995; Wiklund, 2001).

In this study, HVES-applied carcasses were tenderer and characterized by greater stability in colour than the control group 7 days post-mortem. These findings were similar to those of other studies on cattle carcasses (Eikelenboom *et al*., 1985; Hope-Jones *et al*., 2012; Hwang and Thompson, 2001; Smulders *et al*., 1989).

Meat in the HVES group on the 7th day was a better red colour than in the control group. These findings showed similarity with the report of Eikelenboom *et al*. (1985) and Cetin and Topcu (2009), who found improvement in meat. McKenna *et al*. (2003), King *et al*. (2004) and Ledward *et al.* (1986) found no differences between the ES and control group.

HVES increased the evaporative loss of conventionally chilled carcasses 0.38% more than control group ($P<0.05$). Gigiel and James (1984) reported the weight loss from chilled pork meat was 1% less than control group. Janz *et al*. (2001) reported evaporative losses significantly greater than control group. But, McGeehin *et al*. (2002) reported that the evaporative losses for lamb carcasses did not differ from control group.

Conclusions

High Voltage Electrical Stimulation is one of the post-slaughter methods to be used for increasing meat quality. A pH decrease and improvement in colour and tenderness occurred in beef meat after applying HVES. It is concluded that HVES is a useful tool in avoiding cold-shortening of meat and obtaining high quality meat.

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