EFFECTS OF ELECTRICAL STIMULATION OF WETHER LAMBS CARCASSES

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Background

Many studies have been conducted in the past on the effects of weight and sex on the production, chemical composition, acceptability and palatability of lamb meat. The use of wether lambs for meat production is traditional (Lirette et al., 1984); however, there is some question about the palatability of meat from wethers of different weights. Most research attempts to improve palatability of meat from wether lambs have involved *ante mortem* factors such as genetic improvement, weight and diet. Little research has been conducted to determine if some of the palatability attributes of wether lambs can be improved by *post mortem* factors. Tenderness is probably the most important organoleptic characteristic of red meat (Koohmaraie, 1992). The discovery that muscle shortening is one of the major cause of meat toughness has led to the realization that *post mortem* treatments far outweigh live-animal factors such as breed, age and preslaughter state in determining palatability (Cross, 1979; Ouali, 1990). Locker and Hagyard (1963) firstly demonstrated that early exposure of carcasses to cold induces muscle shortening, "cold shortening", and that such shortening can induce toughness. Electrical stimulation of muscles soon after slaughter hastens the onset of *rigor mortis* and provides the basis for processes to rapidly reduce muscle pH in lamb and thus avoid the toughening effects of cold shortening and thaw shortening (Carse, 1973; Chrystall et al., 1980, 1984; Hagyard et al., 1980; Petersen et Blackmore, 1982; Polidori et al., 1999; Lee et al., 2000; Geesink et al., 2001). Although there is little doubt as to the advantage of electrical stimulation, agreement on the optimum conditions for its use has not been forthcoming (Morton et Newbold, 1982). Each research group has developed its own system, using a wide range of voltages, waveforms, pulse rates, times after slaughter, durations of stimulation and methods of applying the stimulus to the carcass (Polidori et al., 1996).

Objectives

This study was conducted to investigate the effects of a low voltage (50 V) electrical stimulation on glycolytic rate of muscle *Longissimus thoracis* and on some of the quality characteristics and palatability attributes of meat from wether lambs.

Methods

Forty crossbred wether lambs from the same environment and fed with the same diet, yielding carcasses with a mean weight of 40 kg, were slaughtered, suspended by their hind legs from a bleeding rail immediately after slaughtering, exsanguinated and divided into two groups. The first twenty lambs were electrically stimulated five minutes after slaughtering using a clip on the nostrils and a rectal probe: the stimulator setting was 50 Volts, 60 Hz frequency, 60 sec; the second group was used as an unstimulated control. Dressing operations of all the carcasses were completed approximately 30 min after slaughtering, then all the carcasses were stored in a cold room at a temperature of 1°C. The internal temperature of the *Longissimus thoracis* (LT) muscle was measured in all the carcasses using a temperature probe at 1, 3, 6, 10 and 24 h after slaughtering. The pH values of the same muscle were determined at the same times inserting a pH probe 2.5 cm below the surface of the muscle. Twenty-four h after slaughtering, from all the carcasses, muscles LT were excised and sub-divided into two portions: each portions was placed separately into labelled polyethylene bags and put in a cold room at a temperature of 1°C. Samples of LT for palatability tests were removed seven days after slaughtering from the cold room and roasted in a metal tray to an internal temperature of 75°C (monitored with thermocouples) in a 170°C gas oven (Riley et al., 1981). Samples were cooled to room temperature (25°C) for 30 min, then from each sample many cores (1.3 cm in diameter) were removed. Shear force value was determined on five cores for each sample, using a Warner-Bratzler operating mounted in an Instron Universal Testing machine. The cores were cut in a longitudinal direction using a mechanical coring device. Peak or maximum shear force was expressed in kg/cm^2. The remaining chops removed from each sample of muscle LT, designated for sensory panel analysis, were evaluated, while warm, by a 20-member trained sensory panel for the following characteristics: flavour desirability and overall palatability (8 = extremely desirable, 4 = slightly undesirable, 1 = extremely undesirable), and tenderness (8 = extremely tender, 5 = slightly tender, 1 = extremely tough), according to the instructions of Bowling et al. (1978). Data obtained in this study were analysed by the method of least squares using G.L.M. procedure of the SAS Institute (1996).

Results and discussion

As soon as the stimulating power was turned on, all the muscles of carcasses contracted, and a slight tremor was evident in the upper limbs. After about 40 sec of stimulation a slow relaxation began, which continued until the power was turned off; the entire carcass then sagged as the muscles relaxed completely. The time course of pH fall in muscle LT of stimulated and unstimulated carcasses, an indication of the rate of *rigor* onset (Chrystall et Hagyard, 1976), is given in Table 1. Stimulation caused a significant ($P<0.05$) acceleration of glycolysis at 1 and 3 h after slaughtering compared with that in unstimulated carcasses. The ultimate pH (24 h after slaughtering) in both stimulated and unstimulated carcasses was about 5.5.

The temperature values recorded during the first 24 h after slaughtering are presented in Table 2; carcasses electrically stimulated had significant ($P<0.05$) lower carcass temperature at 1 and 3 h after slaughtering. It is not the effect of electrical stimulation alone, but the combined effect of electrical stimulation and muscle temperature that determines the rate of pH fall, and thus the extent of tenderizing (Marsh et al., 1988). For this reason, the pH value determined 3 h after slaughtering appears to be the most important parameter: it is a catch-all resultant of all the factors affecting glycolytic rate, primarily stimulation and temperature, and as such it obviates the need for separate evaluations of these variables.

Mean panellist scores for sensory attributes for stimulated and control group are given in Table 3. No significant differences were found between control and treated group as regard flavour desirability, overall palatability and overall tenderness. These results partially agree with a previous study conducted by Savell et al. (1977), in which flavour score for lambs from the electrically stimulated sides were not significantly different than those from the control sides. Electrical stimulation had no significant effects on the shear force values determined with a Warner-Bratzler Shear equipment (Table 3); also in other similar studies conducted in the past, electrical stimulation does not always result in tenderization, as reviewed by Chrystall et Devine (1992).

The main chemical events in *post mortem* muscle are the conversion of glycogen to lactate, with consequent fall in pH value, loss of Creatine Phosphate and ATP, and increase in inorganic orthophosphate (Morton et Newbold, 1982). Many authors consider high voltage electrical stimulation more effective than low voltage stimulation in reducing the time during which muscles remain susceptible to cold or to thaw shortening; on the other hand, many scientists agree that low voltage is more practical and more attractive for application under commercial conditions for safety reasons (Polidori et al., 1996). In general, the lower the voltage, the less the danger to the operator and the less stringent

the requirements imposed by electricity authorities for guarding of carcass and equipment. In a previous study conducted on electrically stimulated heavy lambs (55 kg), Carpenter et Solomon (1995) found an increase in shear force value in lamb chops stimulated with low voltage (21 V). Probably, electrical stimulation was not effective in reducing toughness and modifying palatability characteristics because of the age and the weight of the animals utilized in that experiment. Marsh et al. (1988) stated that electrical stimulation of fat carcasses, and thus slower-cooling, usually fails to increase tenderness, because their non-stimulated glycolytic rate is probably already close to the optimum. Finally, the influence of muscle and animal type is much more important than electrical stimulation in determining meat eating qualities as overall palatability and tenderness, according to the results obtained by Valin et al (1981). In this study, effects of a low voltage electrical stimulation appear to be limited in accelerating glycolytic process in muscle LT of wether lambs carcasses.

Pertinent literature

Bowling R.A., Smith G.C., Dutson T.R., Carpenter Z.L. (1978) J. Food Sci. 43:502-514.
Carpenter C.E., Solomon M. (1995) Proc. 41° ICOMST., S.Antonio, TE, paper E 39, pp. 620-621.
Carse W.A. (1973) J. Fd. Technol. 8:163-166.
Chrystall B.B., Hagyard C.J. (1976) N. Z. J. Agric. Res. 19:7-11.
Chrystall B.B., Devine C.E. (1992) Encyclopedia of Food Science and Technology, J. Wiley & Sons, Inc., N.Y. Vol. 3, pp. 1669-1678.
Chrystall B.B., Devine C.E., Davey C.L. (1980) Meat Sci. 4:69-78.
Chrystall B.B., Devine C.E., Ellery S., Wade L. (1984) N.Z.J. Agric. Res. 27:513-523.
Cross H.R. (1979) J. Food Sci. 44:509-514.
Geesink G.H., Mareko M.H.D., Morton J.D., Bickerstaffe R. (2001) Meat Sci. 57:265-271.
Hagyard C.J., Hand R.J., Gilbert K.V. (1980) N.Z J. Agric. Res. 23:27-31.
Koohmaraie M. (1992) Biochimie 74:239-245.
Lee S., Polidori P., Kauffman R.G., Kim B.C. (2000) J. Food Sci. 65:786-790.
Lirette A., Seoane J.R., Froehlich D. (1984) J. Anim. Sci. 58:1343-1357.
Locker R.H., Hagyard C.J. (1963) J. Sci. Fd. Agric. 14:787-793.
Marsh B.B., Ringkob T.P., Russell R.L., Swartz D.R., Pagel L.A. (1988) Proc. Recipr. Meat Conf. 41:113-118.
Morton H.C., Newbold R.P. (1982) Meat Sci. 7:285-297.
Ouali A. (1990) J. Muscle Food. 1:129-165.
Petersen G.V., Blackmore D.K. (1982) N. Z. Vet. J. 30:195-198.
Polidori P., Kauffman R.G., Valfrè F. (1996) Ital. J. Food Sci. 3:183-199.
Polidori P., Lee S., Kauffman R.G., Marsh B.B. (1999) Meat Sci. 53:179-182.
Riley R.R., Savell J.W., Smith G.C., Shelton M. (1981) J. Anim. Sci. 52:522-529.
SAS (1996) Statistical Analysis System, SAS Institute, Cary, North Carolina.
Savell J.W., Smith G.C., Dutson T.R., Carpenter Z.L., Suter D.A. (1977) J. Food Sci. 42:702-796.
Valin C., Touraille C., Ouali A., Lacourt A. (1981) Sciences des Aliments 1:467-476.

Table 1. Muscle pH measurements between the treatments during *post mortem* time periods (mean±s.e.)

Time (h)	Electrically stimulated	Control
1	6.31±0.04[a]	6.78±0.06[b]
3	5.88±0.03[a]	6.11±0.04[b]
6	5.75±0.02[a]	5.89±0.02[a]
10	5.66±0.02[a]	5.74±0.02[a]
24	5.58±0.02[a]	5.55±0.01[a]

(Different superscripts, within a raw, stand for significant differences, P<0.05)

Table 2. Muscle temperature (°C) measurements between the treatments during *post mortem* time periods (mean±s.e.)

Time (h)	Electrically stimulated	Control
1	36.6±0.4[a]	37.8±0.6[b]
3	16.1±1.0[a]	17.3±0.8[b]
6	5.12±0.6[a]	5.99±0.8[a]
10	1.61±0.2[a]	1.70±0.2[a]
24	0.08±0.02[a]	0.09±0.01[a]

(Different superscripts, within a raw, stand for significant differences, P<0.05)

Table 3. Sensory panel ratings and Shear Force Values for muscle LT measured 7 days after slaughtering (mean±s.e.)

Trait	Electrically stimulated	Control
Flavour desirability[†]	5.9±0.8[a]	5.5±0.7[a]
Overall palatability[†]	5.7±0.9[a]	5.6±0.7[a]
Overall tenderness[†]	5.2±0.8[a]	4.8±0.5[a]
Warner Bratzler Shear Force (kg/cm)	4.3±0.4[a]	4.2±0.7[a]

(†: 8 = extremely desirable or tender; 1 = extremely undesirable or tough).
(Different superscripts, within a raw, stand for significant differences, P<0.05)