# Effect of extra low voltage electrical stimulation on the tenderness of beef sternocleidomastoid muscle

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## Introduction

Many researchers have studied the tenderness of meat from carcasses subjected to electrical stimulation and then to quick chilling. They agree, mainly on the basis of the results of taste panel tests and on Warner-Bratzler measurements, that meat treated in this way is more tender.

Most of the studies on electrical stimulation and meat tenderness have been carried out at high voltage (Chrystall and Hagyard, 1976; Gilbert and Davey, 1976 - 1,600 V; Gilbert, 1978 - 1,100 V; Bendall et al., 1976; Taylor et al., 1980 - 700 V; McKeith et al., 1980 - 550 V; Savell et al., 1978 - 440 V; Bendall, 1976 - 250 V). Nevertheless, certain authors state that the use of low and extra low voltage is also effective in tenderizing meat.

In recent years work has been undertaken on the use of extra low voltage electrical stimulation, which, because of its safety and economy, is more attractive for commercial applications and as effective as high voltage stimulation. According to certain authors (Fabiansson et al., 1979; Nilsson et al., 1979 - 15 V; Ruderus, 1980 - 20-40 V; Valin and Vigneron, 1980 - 20-80 V; Taylor and Marshall, 1980 - 32 V; Powell et al., 1983; Bouton et al., 1980a, 1980b, and 1980c; Buts et al., 1982 - 45 V), extra low voltage systems prevent cold shortening, thereby preventing the toughening of meat.

The object of the present study was to evaluate the effects of extra low voltage stimulation on the tenderness of quick-chilled beef, using a prototype direct-current electrical stimulator offering a versatile range of voltages, impulses, and effective values.

## Materials and Methods

The samples used in the study were obtained and prepared at the "CYPISA" slaughterhouse from 1-year-old animals with a dressed weight of between 250 and 300 kg. The muscle used was sternocleidomastoid muscle, which was removed five to ten minutes after bleeding, stimulated, and immediately packaged in polyethylene bags and quick-chilled in crushed ice.

The muscles removed from the animals were treated in the following manner: lot no. 1: held for 24 hours at 15 ºC with no prior refrigeration; lot no. 2: muscles taken from unstimulated carcasses quick-chilled to 0 ºC; and lot no. 3: muscles taken from stimulated carcasses and quick-chilled to 0 ºC. All the muscles used in the study were stored for ten days in a refrigerator at 2 ºC, and analyses were performed at 0, 3, 5, and 11 days.

Extra low voltage electrical stimulation was effected using an 80-V (peak), square-wave, direct current electrical stimulator, a pulse time of $7 \times 10^{-2}$ seconds, and a frequency of 14.3 Hz. The pulse time delivered by the device can be regulated between $1.3 \times 10^{-3}$ and $35 \times 10^{-3}$ seconds, with a delivered output voltage variable between 1.5 and 40 V. In the experiment an average output voltage of 20 V was used, with an electrical stimulation time of 2 minutes. One electrode was inserted in the nose and the other connected to a stainless steel hook inserted in the anus.

### Kramer shear cell toughness analysis

Both instrumental and sensory toughness analysis were performed after cooking the muscle at 100 ºC in a water bath for 40 minutes.

Instrumental texture analysis was carried out using a model 1140 Instron texturometer to measure the shear strength using a Kramer shear cell. The muscle was allowed to cool to room temperature (20 ºC) and then cut into six portions measuring 1.5 x 1.5 x 5 cm each. Head drive was 100 mm/min and paper speed was 80 mm/min. Peak height on sample weight was used as the measurement for this parameter (kg/g).

### Sensory analysis

Sensory analysis was conducted by a six-member taste panel made up of semi-trained laboratory staff members using a step scale. The parameters rated using the scale were toughness (7 = very tough; 1 = very tender) and overall acceptability (7 = very good; 1 = very poor).

### Cooking loss

The muscle portions used for texture analysis (Kramer shear cell) were weighed before and after cooking. The percentage of liquid released was taken as the cooking loss.

### Statistical analysis

The degree of significance among the means was determined by analysis of variance using an F test. The degree of significance of the correlations was evaluated using Lamotte's tables (1981).

## Results and Discussion

The results of the toughness analysis of the muscle can be seen in Table 1. For the muscles in lot no. 1, held at 15 ºC for 24 hours, shear strength measured by the Kramer shear cell was lower over the storage period at 2 ºC, indicating tenderizing of the meat with time. The maximum toughness that occurs in the muscle during rigor mortis was not recorded, since it has normally subsided after three days in storage, when the analysis was carried out. However, the study of rigor mortis was not one of the objectives of the experiment. With regard to the stimulated or unstimulated quick-chilled muscle, the opposite effect as that found for the lot held at 15 ºC was observed, although higher shear strength values were recorded in the initial analysis for the lot stimulated at 20 V than for the other two lots due to the muscle contraction caused by the electrical stimulation, which was prolonged in the experiment by the refrigeration system used. Similar results were reported by Taylor and Marshall (1980) for beef carcasses stimulated at extra low voltage (32 V) and by Bendall (1976), Bendall et al. (1976), and Chrystall and Hagyard (1976) for high voltage. Significant tenderizing was observed in the stimulated lot on the third day of storage. Bouton et al. (1980b) noted that in veal stimulated at 45 V, higher tenderness levels occurred in muscles removed from the carcass 22 hours after slaughter compared with those removed after 1 and 2 hours, which were tougher.

Except in the case of the stimulated samples, the taste panel detected no significant differences in toughness over the storage period. However, while significant differences were observed in the shear strength, there was still good correlation between the results of both these tests ($r = 0.56$, $P < 0.01$).

Table 1. Toughness measured by Kramer shear cell (KSC) and taste panel (TP) analysis

| Lot | Analysis | Days in Storage 0 | 3 | 5 | 11 |
|---|---|---|---|---|---|
| Held at 15 ºC | KSC (kg/g) | $20.5^{a}_{1}$ | $19.4^{ab}_{1}$ | $18.6^{bc}_{1}$ | $17.4^{c}_{1}$ |
| Unstimulated | " | $19.4^{a}_{1}$ | $22.6^{b}_{2}$ | $28.4^{c}_{2}$ | $24.5^{b}_{2}$ |
| Stimulated | " | $24.3^{a}_{2}$ | $17.1^{b}_{1}$ | $23.6^{a}_{3}$ | $28.2^{c}_{3}$ |
| Held at 15 ºC | TP | - | $5.6^{a}_{1,2}$ | $5.4^{a}_{1}$ | $4.3^{a}_{1}$ |
| Unstimulated | " | - | $6.8^{a}_{1}$ | $6.3^{a}_{1}$ | $5.6^{a}_{1,2}$ |
| Stimulated | " | - | $4.8^{a}_{2}$ | $6.2^{ab}_{1}$ | $6.8^{b}_{2}$ |

The different letters in each row and the different numbers in each column indicate significant differences ($P < 0.05$)

Analysis of variance of the data on shear strength (Table 2) as measured with the Kramer shear cell and evaluated by the taste panel showed significant differences between the lots treated by holding at 15 ºC and the stimulated and unstimulated, quick-chilled lots. However, the results obtained for the stimulated and the unstimulated lots showed no significant differences, which means that muscles from stimulated carcasses were no more tender than those subjected to quick-chilling alone (cold-shortening). On the other hand, muscle held at 15 ºC was more tender.

Table 2. Analysis of variance for toughness measured by Kramer shear cell and taste panel determination

| | Toughness: Kramer shear cell | Taste panel |
|---|---|---|
| Held at 15 ºC/unstimulated | ** | ** |
| Held at 15 ºC/stimulated | ** | * |
| Unstimulated/stimulated | NS | NS |

* $P < 0.1$ ** $P < 0.01$ NS = Not significant

Water holding capacity may be related to toughness (Table 3). In the present experiment it was determined as the cooking loss (by weight), and, though the correlation coefficient was not calculated, it would not appear to be good. A slightly greater water holding capacity was observed in the lot held at 15 ºC compared to the water holding capacity of the other two lots.

Table 3. Cooking loss (%) during storage

| Lot | Days in storage 0 | 3 | 5 | 11 |
|---|---|---|---|---|
| Held at 15 ºC | 30.8 | 32.9 | 35.7 | 32.8 |
| Unstimulated | 34.1 | 31.6 | 43.1 | 35.9 |
| Stimulated | 35.4 | 31.0 | 39.3 | 35.7 |

Table 4. Overall acceptability by taste panel analysis

| Lot | Days in storage 3 | 5 | 11 |
|---|---|---|---|
| Held at 15 ºC | 4.2 | 4.0 | 4.4 |
| Unstimulated | 3.0 | 3.0 | 3.0 |
| Stimulated | 4.2 | 2.4 | 2.4 |

The scale used ranged from 7 (very good) to 1 (very poor)

The overall acceptability of the meat as determined by sensory analysis (Table 4) indicated that the acceptability of the sample held at 15 ºC was higher than that of the other two samples. It should be noted that, while the acceptability of the stimulated lot declined during storage, the acceptability of the other two lots remained stable. The acceptability rating depends on the toughness of the muscle, which was high in the lot held at 15 ºC, perhaps because of special characteristics of the muscle tissue used.

On the basis of the results obtained, it can be concluded that extra low voltage stimulation of beef carcasses had no significant effect under the conditions of the present experiment. Buts et al. (1982) reported similar results concerning the toughness of sternocleidomastoid muscle. These findings may be due to the fact that this muscle is not the most appropriate for studying the effects of electrical stimulation, as suggested by Bouton et al. (1980a). Taylor (1981) pointed out that extra low voltage stimulation may not be effective for certain beef muscles. Salé (1980) found that the effectiveness depended on the position of the electrodes (the electrical field) and on the waveform, which act differently on different muscles (Bouton et al., 1980c).

Nonetheless, various studies recommend the use of extra low voltage (Shaw and Walker, 1977; Fabiansson et al., 1979; Nilsson et al., 1979; Ruderus, 1980; Taylor and Marshall, 1980; Eikelenboom et al., 1981; etc.) in view of the benefits of the technique. As a result, further research in this area would appear to be extremely important in order to determine the most appropriate electrical parameters, so that the proposed stimulator prototype can be used effectively to prevent cold-shortening in beef.

Acknowledgement
Part of the work involved in this study was carried out at the GYPISA slaughterhouse, and thanks are extended to that firm's manager, Mr. Durán, and technical director for sanitation, Mr. Jiménez, for their cooperation, without which this experiment would not have been possible.

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