# METHOD FOR AUTOMATIC CONTROL OF ELECTRICAL STIMULATION OF CARCASSES

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## SUMMARY

A method for automatic control of the efficiency of electrical stimulation (ES) of carcasses has been developed. It is based on the measurement of the rate of the carcass impedance alteration during stimulation and on its com-parison with a fixed, experimentally found value.

Experiments were made with 25 Bulgarian 'Black and White' young bulls.

The experimental results suggest that the method might be applied for automatic interruption of ES when it is no longer effective and for early detection of pronounced DFD meat.

## INTRODUCTION

A criterion which is often used for estimation of the efficiency of electrical stimulation is the pH drop in representative muscles (Shaw and Bouton 1980; Chrystall and Devine 1982; Ruderus and Fabiansson 1982; Asghar and Henrickson 1982; Hofmann 1987 etc.). The effect of ES depends on a number of factors some of which are connected with the species, breed, sex, age, lairage in farms, rearing, transport, physiological state and treatment before slaughter. In spite of the different individual peculiari-ties of each carcass, in the slaughterhouses normally all carcasses are subjected to ES with a fixed duration, usually ranging from 30 to 120 s. But the meat of some carcasses is DFD and it is not necessary to stimulate them because Dutson **et al.**(1982) have found that ES does not influence DFD meat quality. The initial pH of carcasses of exhausted animals is relatively low and there is no use to stimulate such carcasses as well (Crystall **et al.** 1978). For carcasses with normal meat ES should be stopped when the rate of pH drop becomes smaller than a definite value (Chrystall **et al.** 1978). It is evident that the duration of ES may be controlled depending on the rate of pH drop during stimulation.

At present, the measurement of pH during ES for the sake of process control is not possible because of the slow response of pH-meters and the necessity to interrupt the process. Owing to the relationship between pH and the elec-trical impedance $z$ of the carcass (or parts of the carcass) and because the electrical impedance could be measured during the process of stimulation it may be used for control of the efficiency of ES (Tsankov **et al.** 1987).

The aims of the present study were:

1) To find a method (criterion) for automatic inter-ruption of ES based on the relative alteration of the elec-trical impedance $z$ of a muscle.

2) To study the possibility for early detection of pronounced DFD meat.

## MATERIALS AND METHODS

Animals and experimental groups. Twenty five Bulgarian 'Black and White' young bulls of the same age (16-18 months) and approximately the same live mass (300-350 kg) were used. They were divided into three groups - A, B and C and tran-sported from a farm 25 km away from the slaughterhouse.

Group A and group B consisted of 10 bulls that had been fed and reared under the same conditions. They were stunned and slaughtered in the usual way within an hour and a half after arrival.

After transportation the animals from group C, consist-ing of 5 bulls of two different herds, were let loose together for three hours in an open pen so that they could reproducibly develop DFD meat (Fjelkner-Modig and Ruderus 1982). After that they were stunned and slaughtered in the usual way.

All groups were subjected to ES. Stimulation of group A was interrupted twice.

**Electrical stimulation.** After dressing, within 15 min after slaughter, all carcasses were stimulated for 2 min with square unipolar pulses 85 V (peak), duration - 10 ms, frequency - 14.3 pps. ES of group A was interrupted at the 15-th and 60-th second in order to measure pH and $z$. The negative electrode of stainless steel (diameter - 6 mm, length - 150 mm) was inserted in the muscles around

TABLE 1.

| $t_{ES}$ [s] | Groups | $D_p$ [%] | | $D_{pH}$ [%] | | $D_z$ [%] | |
|---|---|---|---|---|---|---|---|
| 15 | A | 20.9 | 4.2 | 6.42 | 0.35 | 5.63 | 0.44 |
| | B | 23.1 | 4.1 | - | | - | |
| | C | 4.6 | 1.9 | - | | - | |
| 30 | A | - | | - | | - | |
| | B | 29.5 | 4.2 | - | | - | |
| | C | 6.3 | 1.8 | - | | - | |
| 45 | A | - | | - | | - | |
| | B | 36.1 | 3.7 | - | | - | |
| | C | 8.1 | 2.0 | - | | - | |
| 60 | A | 43.8 | 4.3 | 8.25 | 0.35 | 7.76 | 0.42 |
| | B | 41.5 | 4.1 | - | | - | |
| | C | 8.9 | 2.0 | - | | - | |
| 75 | A | - | | - | | - | |
| | B | 44.0 | 3.8 | - | | - | |
| | C | 9.3 | 1.7 | - | | - | |
| 90 | A | - | | - | | - | |
| | B | 45.6 | 3.3 | - | | - | |
| | C | 9.5 | 1.9 | - | | - | |
| 105 | A | - | | - | | - | |
| | B | 46.4 | 3.2 | - | | | |
| | C | 9.6 | 1.8 | - | | - | |
| 120 | A | 49.5 | 4.1 | 8.48 | 0.40 | 8.01 | 0.48 |
| | B | 46.7 | 3.2 | 8.45 | 0.37 | 7.97 | 0.45 |
| | C | 9.7 | 1.8 | 1.48 | 0.21 | 1.45 | 0.25 |

$t_{ES}$ - time from the beginning of ES; $D_p$ - relative alteration of number of pulses; $D_{pH}$-relative alteration of pH in LD; $D_z$ - relative alteration of electrical impedance.

the Achilles tendon of the hind legs. The positive electrode was a clamp connected to the interceptum of the animal's nose and inserted about 5 cm. The stimulating unit permitted monitoring of the contact between electrodes and carcass based on the values of the flowing electric current. The stimulating pulses were monitored on the screen of a TEKTRONIX 2213 oscilloscope.

**pH measurement.** pH of all carcasses was measured before and after ES. pH of the carcasses of group A was measured in the 15-th and 60-th second as well. The measurement was made in *M.longissimus dorsi* (LD) with a portable digital pH-meter (METROHM AG 604 E) with a combined Ingold electrode (I0641). Depth of measurement was about 5 cm. The probe electrode was moved to three different positions within the muscle, read-ings were observed, and the different values were mentally averaged. Before each measurement the electrode was rinsed with distilled water and between measurements it was kept at 38 - 39°C. Before pH measurement of each carcass the meter was calibrated against a 'buffer' solution of pH 7.0.

**Measurement of** $z$. In order to measure the electrical impedance, before and after ES, sinusoidal voltage was applied (1 kHz, 10 V RMS) via two additional measuring electrodes. The voltage was supplied by a functional gene-rator TEKTRONIX FG 507 and was monitored on the screen of a TEKTRONIX 2213 oscilloscope. For group A the voltage was also applied in the 15-th and 60-th second. The additional cylindrical stainless steel electrodes (diameter-2 mm) were inserted 50 mm deep in *M.longissimus dorsi*, the distance between them being 200 mm. The flowing electric current was measured with a digital multimeter. The carcass impedance was calculated in accordance with Ohm's law.

Information about the impedance of the carcasses from all groups was obtained with the help of a specially design-ed unit (Tsankov **et al.** 1985) - an electronic counter of the pulses delivered by a generator. Via measuring electrodes the carcass impedance was connected in the feedback of the generator and the pulse frequency depended on it. Pulses were supplied to the counter only during the interval be-tween stimulating pulses in the course of 440 ms. For group B and C their number was registered at the beginning of ES and after each 15 s until the end of stimulation. The number of the pulses for group A was counted only in the beginning, at the 15-th, 60-th and 120-th second.

**Temperature measurement.** The temperature was measured with an electronic digital thermometer with accuracy up to 0.1°C.

## RESULTS AND DISCUSSION

The experimental results were transformed using the formula

$$D_x = 100.\mathrm{mod}(x_t/x_o - 1),$$

where: $x_o$ - value of the measured quantity before or after the beginning of stimulation ; $x_t$ - value of the measured quantity after stimulation for t seconds.

The results of the statistical analysis (mean value $\pm$ standard deviation) are given in Table 1. All calculations were performed using a standard software statistical package on an Intelle XT personal computer ($p = 0.05$).

During stimulation the temperature variations were within the range of 0,5 - 1 °C.

The analysis of the corresponding values for $D_{pH}$, $D_p$ and $D_z$ of group A and group B showed that they were not significantly different. After 45-th second the values of $D_p$ for group C were not significantly different as well. In the 60-th and 120-th second the differences between the values of $D_p$, between the values of $_{pH}$ and between the values of $D_z$ of group A were not significant either.

Regression analysis was applied and it confirmed the relationship between $D_z$ and $D_{pH}$ found by Tsankov **et al.** (1987) and the existence of a similar relationship between $D_p$ and $D_{pH}$ was detected. The coeficient of correlation was $r = 0.91$ and it was found to be significant.

The results suggest that the control of the duration of ES could be achieved through the use of the relative impe-dance alteration in representative muscles (e. g. LD). Its measurement should be made in the interval between stimulat-ing pulses so that they will not influence the measurement. The insertion of measuring electrodes has got some disadvan-tages like additional operations, damage of skin if stimula-ting before dressing, etc. A possible way to eliminate these disadvantages is to use the stimulating electrodes for measurement as well, provided they are inserted in muscles using the aforesaid unit.

From the applied method of measurement it becomes clear that if the rate of $D_p$ alteration is greater than 5 % for 15 s, the process of stimulation should go on because the alterations are significant and ES is effective. This was true for the first 60 s of stimulation of group A and group B. The process sould be stopped when the rate of $D_p$ alter-ation becomes less than 5 % for 15 s.

If the rate of $D_p$ alteration is less than 5 % in the first 15 s from the very beginning of ES the process should be stopped and the carcass should be considered a carcass of low quality meat. Additional measurement of pH is necessary to classify it as DFD meat or meat from an exhausted animal (with low initial pH). All carcasses from group C were classified as low quality meat (three showed pronounced DFD meat).

## CONCLUSIONS

We suggest a method for control of ES of carcasses of ruminants which is characterized by:
- automatic interruption of ES when the efficiency of stimulation is not significant;
- possibility for early detection of pronounced DFD meat.

Because the experiments were carried out under labora-tory conditions and because the number of the animals was relatively small, further investigations in the same field are recommendable.

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