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IMPROVED METHOD FOR ELECTRICAL STIMULATION OF BEEF AND LAMB CARCASSES

D. TSANKOV, IV. MASLINKOV, G. MIHOV

Higher Institute of Food & Flavour Industries
Plovdiv, Bulgaria

SUMMARY

From physiological point of view the response of the carcass is not closely related to the voltage used for electrical stimulation (ES) but to the current density, i.e. to the magnitude of the electric current which depends on the carcass impedance and a number of uncontrolled factors.

Experiments were made with a special unit designed as a current source generating current pulses and a new method for ES with fixed amplitude of electric current was studied. It eliminated the influence of some of the uncontrolled factors because during stimulation the amplitude of the current was automatically kept constant. The efficiency of the new method was confirmed by the steady results concerning the pH drop (ΔpH) and we recommend it for industrial and research application.

INTRODUCTION

The equipment and methods that are used for ES of carcasses of ruminants differ significantly [3,4]. Electric pulses of different type, polarity, frequency and voltage are applied in many research laboratories and slaughterhouses in order to improve meat quality. It is world wide practice to fix the voltage magnitude (peak or rms) and very little attention is paid to the magnitude of the electric current through the carcass resulting from the fixed voltage.

Such an approach of designing and applying units for ES that are voltage sources has got a number of disadvantages which are essential for low voltage ES [7].

From physiological point of view the efficiency of ES depends on the intensity of muscular contraction, i. e. on the extent of nerve and muscle irritation. The physical quantity which is directly connected with the extent of irritation is the current density and its relation to the applied voltage is not very simple and clear enough. That is why it is recommendable to design and use units for ES that are not voltage sources but current sources [1].

The aim of the present paper is to evalu- ate the efficiency of ES by measuring ΔpH and to study the influence of the uncontroll- ed transition resistance between the two elec- trodes of the stimulating unit upon the dis- tribution of electric potential along the carcass when applying a new method for ES.

MATERIALS AND METHODS

Experiment 1. Twenty Thracian fine-fleec Bulgarian breed lambs of live weight 20 - 25 were used. The animals that had been bred transported and treated under similar condi- tions were divided equally into four group (A1, A2, A3, A4). After bleeding and dress- ing (within 8 - 10 min after slaughter) they were stimulated electrically for 1.5 min wi current unipolar square pulses with the fol- lowing characteristics: frequency - 14.3 pps duration - 5 ms; amplitude - 50 mA, 100 mA, 150 mA and 200 mA for A1, A2, A3 and A4 res- pectively. The railway served as the nega - tive electrode and the positive one was a three-point electrode of stainless steel in- serted in the neck muscles (diameter - 4 mm). After dressing the lambs were hung from the Achilles tendon via a hook suspended from the conveyor rail with grease on it.

Experiment 2. Ten Black and White Bulgari breed young bulls, 18 - 20 months old, live weight 420 - 480 kg were used. The animals that had been bred, transported and treated under similar conditions were divided equall into two groups (B1, B2). After bleeding (with- in 8 - 10 min after stunning) they got the same treatment as that of Experiment 1 but the amplitude of the current pulses was 200 mA fo B1 and 400 mA for B2. Besides, ES took place before dressing and the positive electrode wa a nose-clamp.

The carcasses were stimulated with a speci- ally designed current source with the follow- ing characteristics of the output unipolar current pulses: amplitude - up to 0.5 A; pul- se duration - from 1 to 20 ms; interval bet- ween pulses - from 10 to 100 ms.

In both experiments during ES we measured the voltage between the two electrodes - U and the potential differences between some characteristic points - U_{ab}, U_{bc}, U_{cd}, U_{de} and U_{fg} (Fig. 1). The measurements were ca-

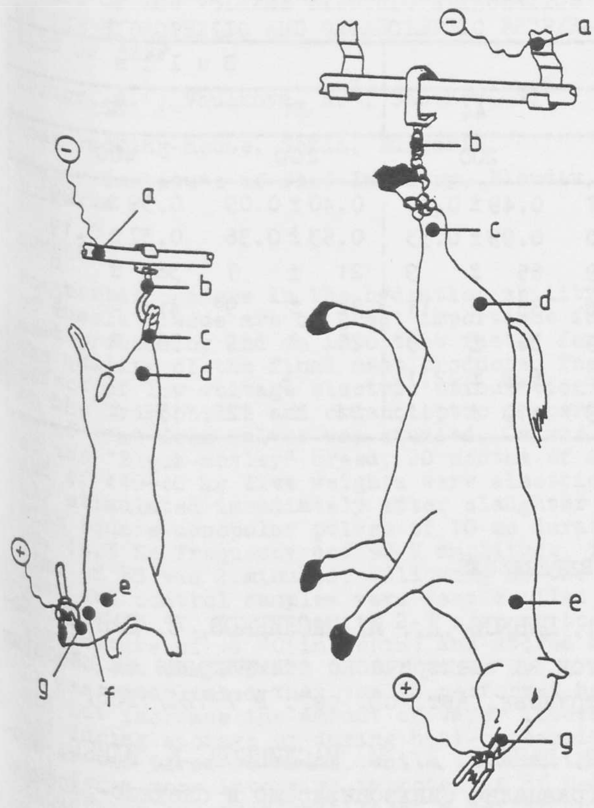

Fig.1. Place of location of measuring and stimulating electrodes

rried out with a specially designed unit [2] with accuracy up to 3 % while the shape of the pulses was observed on the CRT of a Tektronix 2215 oscilloscope.

The efficiency of ES was evaluated by the drop of pH in m. Semitendinosus which was measured immediately before and after ES using a portable METROHM 604E pH-meter with a combined electrode.

RESULTS AND DISCUSSION

The experimental results are given in Table 1 in the form $\overline{x} \pm t.s_{\overline{x}}$, where $\overline{x}$ is the mean, $s_{\overline{x}}$ - the estimated standard deviation of the mean, t - the significance limit of the Student distribution (corresponding to N = 5 and desired significance probability P = 0.05).

The variations of the mean values of ΔpH are statistically insignificant and ΔpH for each group is big enough to consider the applied method of ES as efficient (the initial pH for groups A was 6.8 - 6.9 and 6.6 - 6.7 for groups B). It might be interesting to study the relation between ΔpH and the current amplitude if the latter takes values lying outside the studied intervals.

One can notice that only (15 -20) % of the voltage between the electrodes was applied to that part of the carcass which is the most important from commercial point of view (U_{de}). Similar are the results reported in [6]. This means that if the stimulating electrodes are inserted somewhere near points "d" and "e" the maximum voltage amplitude will not exceed 35-40 V which means that if ES is carried out with voltage sources, these are the adequate values for an efficient stimulation.

Quite impressing are the high values of U_{bc} for lambs due to the high resistance of connective tissue and bones in the Achilles tendon region. Similar are the values for U_{ad} of the hind leg which could be explained with the lack of big muscles in the corpus tibiae region and with the small cross-section of the leg. Most probably the high resistance of the tissues around the Achilles tendon is the reason for its melting when stimulating lamb carcasses at 800 V only for 45 s reported in [5]. It should be mentioned that for beef carcasses the values of U_{bc} are smaller, probably because the contact between shackle and carcass is achieved through the hide which has larger contact surface with the carcass.

The suggestion of some authors [7] that the transition resistance between railway and hook may be of great importance for the efficiency of ES was not confirmed by our experiments. Really the values for U_{ab} differ but they are very small and on the whole did not affect the ES. For bulls, these values are even smaller owing to their greater mass and the better contact between railway and shackle.

It is worth noticing that voltages of the same parts vary significantly for the different animals which makes the width of their confidence intervals greater. This fact could be explained with the different position of electrodes in relation to the carcass heterogeneous tissues, with the different pre-slaughter state of the animals as well as with the inaccurate positioning of electrodes in the given points. The different geometry of each

Table 1. ΔpH and voltages of lamb and beef carcasses stimulated with current pulses with different amplitude

	Lambs				Bulls	
	A1	A2	A3	A4	B1	B2
I , mA	50	100	150	200	200	400
ΔpH	0.47 ± 0.12	0.46 ± 0.11	0.45 ± 0.07	0.49 ± 0.10	0.40 ± 0.09	0.39 ± 0.09
U_{ab} , V	1.10 ± 0.45	1.02 ± 0.43	1.02 ± 0.50	0.99 ± 0.33	0.53 ± 0.36	0.37 ± 0.19
U_{bc} , V	23 ± 11	39 ± 8	53 ± 9	65 ± 9	21 ± 7	38 ± 8
U_{cd} , V	25 ± 8	31 ± 12	42 ± 6	55 ± 11	22 ± 9	41 ± 10
U_{de} , V	11 ± 5	15 ± 2	24 ± 5	36 ± 5	27 ± 5	55 ± 6
U_{fg} , V	4.0 ± 1.2	3.8 ± 1.0	4.1 ± 2.2	6.3 ± 2.1	-	-
U , V	65 ± 18	89 ± 13	128 ± 9	170 ± 11	84 ± 12	152 ± 13

stimulated carcass also encreases these voltage variations. When the amplitude of the electric current is costant, these factors lead to cosiderable alterations of the carcass voltage U. Its maximum allowable value must be in conformity with the safety voltage regulations for each country. According to Ohm's law that maximum allowable voltage and the carcass impedance limit the upper values of the stimulating electric current.

During ES we altered the size of the contact surface of the positive electrode in some carcasses in order to study its influence on ES. Such alterations are quite usual for slaughterhouses due to muscular cotraction or contamination of animal nose. In our experiments this lead to a (5 - 10) % change of U. Besides, during ES (10 - 15) % alterations of U were observed in some carcasses. Of course, all these voltage alterations did not affect the amplitude of the stimulating electric current and in spite of them the ES was efficient. If stimulation is carried out with voltage sources they could have some negative or positive effect on the ES efficiency.

Our results suggest that the proposed method for ES of beef and lamb carcasses might have some advantages in comparison with the existing methods and it might be of interest for meat industry and meat research workers.

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