ELECTRICAL STIMULATION OF THE BEEF CARCASS AND ITS PRACTICAL APPLICATION

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Contraction can be stimulated in post-mortem muscles by the application of an electrical voltage as long as the pH remains above 6.3 and ATP is present; energy is expended and the whole process of glycolysis is speeded up. This principle has been utilised in New Zealand to allow the rapid freezing of lamb carcasses without cold-shortening.

The application of electrical stimulation to the beef carcass has been found to accelerate the onset of rigor mortis by about 8 hours and conditions for various practical applications have been defined.

LA STIMULATION ELECTRIQUE DE LA CARCASSE DE BOEUF ET SON APPLICATION PRATIQUE

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La contraction des muscles des carcasses peut être stimulée par l'application d'un voltage électrique aussi longtemps que le pH reste au-dessus de 6,3 et que l'ATP est présent ; de l'énergie se dissipe et tout le processus de la glycolyse est accéléré. Ce principe a été utilisé en Nouvelle Zelande pour permettre la congélation rapide des carcasses d'agneau sans le raccourcissement provenant du froid.

On a trouvé que l'application de la stimulation électrique aux carcasses de boeuf avance le début de la rigidité cadavérique de 8 heures environ et des conditions de divers usages pratiques ont été définies.

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DIE ELEKTRISCHE STIMULIERUNG DES RINDKÖRPERS UND DEREN PRAKTASCHE ANWENDUNG

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Das Zusammenziehen kann bei post-mortem Muskulatur durch die Verwendung einer elektrischen Spannung stimuliert werden, solange der pH-Wert uber 6,3 liegt und ATP vorkommt; Energie kommt zum Wirken und der ganze Glycolyseprozeß wird beschleunigt. Dieses Prinzip wurde in Neuseeland verwendet, um das schnelle Einfrieren von Schafschlachtkörpern ohne Kältekontraktion zu ermöglichen.

Es stellte sich heraus, daß die Verwendung der Elektrostimulierung des Rindkörpers das Eintreten der Totenstarre um etwa 8 Stunden beschleunigt, und die Bedingungen für die verschiedenen praktischen Anwendungen wurden definiert.

ЭЛЕКТРИЧЕСКАЯ СТИМУЛЯЦИЯ МЯСНОЙ ТУШИ И ПРАКТИЧЕСКОЕ ПРИМЕНЕНИЕ

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Сокращение посмертных мышц может быть стимулировано применением электрического вольтажа при том устовии, что рН будет выше 6,3 и присутсвует АТР; энергия истрачивается и целый процесс гликолиса ускоряется. В Новой Зеландии применяли этот принцип для быстрого замораживания мяса молодого барашка без сокращения в замороженном состоянии.

Обнаружено, что применение электрической стимуляции мясных туш ускоряет начало посмертного окоченения на 8 часов, и определены условия для разных практических применений.

ELECTRICAL STIMULATION OF THE BEEF CARCASS AND ITS PRACTICAL APPLICATION

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Electrical stimulation of beef carcasses as soon as possible after slaughter was first suggested by Harsham and Detherage (1951) as a means of accelerating the post-mortem fall of pH and the onset of rigor, with the apparent additional advantage of tenderising the meat. The process had not found commercial application until quite recently, when, in New Zealand, it was developed for use in lamb-slaughtering abattoirs (Chrystall and Hagyard, 1976). New Zealand workers have also studied the process in beef carcasses, mostly dressed out as sides within 50 min of slaughter (Davey, Gilbert and Carse, 1976).

Because of the desirability of stimulating lamb carcasses before dressing, Chrystall and Hagyard (1976) applied the voltage via one electrode contacting the fleece in the middle of the back and a pair of electrodes through the shackles on the hind-legs. Because of the high resistance of the fleece very high voltages (3000-3600V) were necessary. Similar voltages were also employed by Davey et al (1976) for beef sides, although as we shall show this is unnecessary if electrodes are attached to the neck region and the hind-legs (c.f. also Carse, 1973).

In the work reported here we have investigated the effect of voltage, frequency of pulses and pulse duration, in both intact, undressed carcasses immediately after slaughter and in dressed sides within 60 min of slaughter. Stimulation was via two electrodes of one polarity, attached to wet portions of the severed neck, and another pair of opposite polarity, attached to muscles adjacent to the Achilles tendons. The polarity of the electrodes was reversed each 30s of stimulation.

Undressed carcasses responded to pulse frequencies of less than 10 Hz by contracting more or less vigorously, depending on the voltage, in time with the pulses. At voltages above 200V the front limb is extended at right angles to the body-axis, and the neck region of the hanging carcass rises about 20 cm from its rest position. On cessation of stimulation, the carcass relaxes completely to its rest position. Increasing the pulse frequency above 12 Hz, leads to fusion of individual muscle twitches into a tetanus, so that after the initial arching of the back and extension of the front limb, the carcasses remain still in the contracted position without visible muscle fibrillation, while stimulation is proceeding.

Stimulation of dressed sides results in a far more vigorous physical response, because of the absence of contralateral muscles to act as support. The intercostal and longissimus dorsi (LD) muscles contract violently causing the side to bend outwards and upwards; the side falls back rapidly to its rest position on cessation of stimulation.

Table 1 shows the effect of stimulation on the pH fall on 3 major muscles at varying voltage and a constant frequency of 25 Hz (total pulses (S) = 3000), on an undressed carcass at 12 min after slaughter. The optimum effect was obtained at 700V, when the pH falls during stimulation to about 6.25 from the initial pH (pH_o) of about 7.10. This represents the formation of about 50 μmol lactate/g muscle during the 2 min

Table 1

The electrical stimulation of undressed beef carcasses within 15 min of slaughter. The effect of voltage on the pH fall in three major muscles, (LD = longissimus dorsi; BF = biceps femoris; TB = triceps brachii). Frequency of stimulation = 25 Hz; duration = 2 min, with reversal of polarity each 30s. pH_o = initial pH; pH_S = pH immediately after stimulation; pH_F = final pH at 48h after slaughter. Ambient temp = 16°.

Parameter	Voltage	Peak amps	LD	BF	TB
pH_o	0 - 700	-	7.06	7.15	7.14
pH_F	0 - 700	-	5.50	5.49	5.49
pH_S	0	0	7.03	7.09	7.10
	100	1.2	7.00	6.72	6.58
	300	2.7	6.33	6.30	6.52
	700	5.9	6.23	6.30	6.29
Time (h) to pH 6.0	0	-	8.8	8.4	8.6
	100	-	8.0	3.3	4.0
	300	-	1.5	1.2	2.5
	700	-	1.1	1.0	1.1
Time (h) to pH 5.7	0	-	10.7	10.2	10.0
	100	-	10.0	5.2	5.7
	300	-	4.0	2.2	3.5
	700	-	2.0	1.6	1.5

stimulation, corresponding to a turnover of energy-rich phosphate (~P) of about 100 μmol/g. In unstimulated carcasses this fall in pH takes about 6 hours at an ambient temperature of 16°. The pH had fallen to 6.0 within 1.1h of slaughter and to 5.7 within 2h of slaughter, equivalent times at 16°C being 7 or 9 hours without stimulation. At pH 6, 50% of the initial resting content of ATP (6.4 mol/g) had disappeared and at pH 5.7 more than 90%. Rapid cooling of muscles to 2° can be started without danger of cold-shortening as soon as pH 6 is reached, and rapid freezing without danger of thaw-contracture as soon as pH 5.7 is reached. In the case of the stimulated carcasses (700V), rapid cooling can therefore be begun at 1.1h after slaughter, and rapid freezing at 2h.

The stimulation of dressed sides was begun, in our experiments, at 0.85h after slaughter. At 700V, 25 Hz, applied for 2 min, the time from slaughter for the pH of the major muscles to fall to 6.0 was 2.2 to 3.5h and for them to fall to 5.7, it was 3.2 to 4.9h, representing a saving of time, compared with unstimulated carcasses, of 5 to 7.5h. The savings are not as great as with the stimulated undressed carcass, mainly because of the initial delay before stimulation of 0.85h, and partly because of the somewhat lower rate of pH fall in the post-stimulation period.

SUMMARY

Optimal effects are obtained by stimulating carcasses, either intact or as sides, at a voltage of 700V, pulsed at 25 Hz to avoid individual muscle twitches which cause rythmic contractions of the carcass. A minimum of 3000 pulses should be given; increasing the number to 6000 pulses produces a very minor additional effect. It is advantageous to reverse the polarity of the electrodes (between severed neck and Achilles tendons) each 30s of stimulation to avoid excessive polarisation of the electrode metal. Stimulation should begin within 1h of slaughter.

The major practical advantage of electrical stimulation is that cooling or freezing can be started much sooner than normal, in this case, holding space at temperatures above 10°, necessitated by considerations of cold-shortening, is reduced to a minimum, a consideration of major importance in abattoirs handling high throughput of lamb, and rapid cooling brings with it a considerable reduction in weight loss due to evaporation of water from the carcass. Particularly important in our opinion is the possibility of combining stimulation with the hot deboning technique, preferably into single muscles, because then complete control of the post-mortem biochemical and physical changes is within grasp for the first time, by simple manipulation of the cooling procedure. Hot deboning is, in fact, facilitated after stimulation, because the meat is partly set in rigor.

A possible disadvantage of the method arises from the very fact that the pH fall after stimulation is so rapid. pH values below 6 can be obtained within 1.5h of slaughter at which time the temperature in the deep musculature of the beef round could be still above 35°. Conditions of low pH and high temperature are precisely those which obtain in the PSE condition in pork where the meat is pale, unsightly and wet. We have not encountered any serious case of excessive drip loss in meat from stimulated carcasses, and particularly not when the technique has been combined with hot deboning. Much of the meat produced from stimulated carcasses has been sold to a local butcher, who reported that it was of excellent quality.

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