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ELECTRICAL STIMULATION — AN EFFECTIVE METHOD TO PRODUCE MEAT OF HIGH QUALITY

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The influence of electrical stimulation on the quality of meat was studied. Optimum parameters for stimulation in practical meat processing were determined. An automatic in-line-stimulator is shown.

INTRODUCTION

Modern quick-cooling or freezing of meat show economic and hygienic advantages in comparison with conventional methods. In particular the production-technological combination of hot-boning and immediate cold treatment of the vacuum-packed meat is profitable with respect to floor, transport, and manpower capacities as well as to reduction in energy consumption of cold treatment. Benefits according to various authors are summarized in Table 1. Besides these advantages the period of stocking (at -18°C to -20°C) can be extended at least for about 30 per cent due to a low microbiologic attack [7].

But as a disadvantage the quick-cooling of hot-boned meat leads to cold shortening and hereby the lack of tanderness of the meat. To avoid this cold shortening the electrical stimulation of carcasses or parts of it immediately after has been applied as particular food processing technique.

The aim of our studies [12] was to characterize the effect of electrical stimulation on the meat quality, to find optimum stimulation parameters, and to desing an automatic in-line-stimulator for medium slaughter capacity.

MATERIAL AND METHODS

For the experimental work more than 150 cattle and wethers with different biological features (age, sex, slaughter class) were selected for various experi-

Table 1. Reduction of processing capacity and mass loss of meat using the technological combination of hot boning/quick cooling or freezing in comparison to conventional cooling; (given in per cent, cf. ref. 1, 2, 7, 8)

		reduction	ref.
Dissection of meat and processing			
	floor capacity*	25	[8]
	transport	50	[1, 7]
Cold treatment			
	floor capacity*	50-80	[1, 2, 8]
	energy consumption	50-80	[1, 2]
	cooling area	45	[7]
	cold stocking area	45	[7]
	cooling duration	45	[7]
	transport	50	[1, 7]
Mass loss**		1,5	[7]

* by reducting the frozen mass for about 40-50
** with respect to the initial mass

mental groups according to these features and to the anesthetic procedure (mechanically/electrically). Whole carcasses of wether in skin as well as halves and quarters of cattle were stimulated (parameters of stimulation: 40-250 V, 50 Hz, 2-3 min, 10-15 s ES/5 s NES).

Before and after specific cold treatment of the carcasses or parts of it various muscles had been dissected in warm or cold state for investigating the quality extensively (state of contraction, consistency, water holding capacity, drip loss, sensoric quality). Nonstimulated carcasses or sides had been applied for checking.

RESULTS AND DISCUSSION

The essential results can be summarized. Cold shortening starts at the temperature interval of 10°C to 15°C. This is shown in Fig. 1 for particular cattle muscles in comparison with results of other authors. At cooling below 10°C the shortening of muscles increases in all cases. The muscles exhibit the maximum shortening of 30% to 60% at the interval of -1°C to +4°C. The reason for cold shortening is the considerable increase of ATP-turnover below a specific temperature limit of the particular kind of muscle or animal at quick cooling of the meat. The resynthesis of the converted ATP promotes the anaerobic glycogen decomposition. These promotion of the post mortem processes is caused by Ca^{2+} ions which induces below the specific temperature a strong cold shortening by an analogous mechanism as for the physiological muscle contraction due to their enrichment in the interfibril space.

Only conctraction of the muscles of more than 15% to 20% exhibits a sensoric detectable and inadmissible increase of toughness as can be seen in Fig. 2

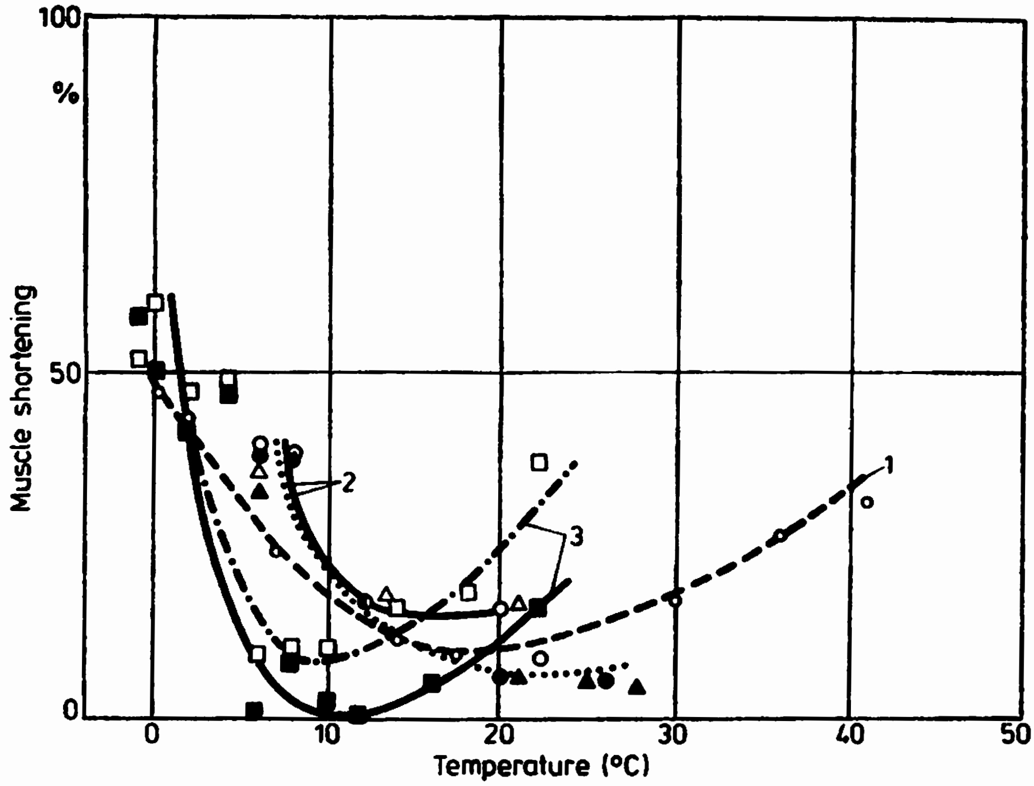

Fig. 1. Muscle shortening in dependence on temperature for cattle; 1 cf. Locker and Hagyard [10]; 2 cf. Specht et al. [14]; ○ — *M. psoas major*, ● — *semimembranosus*; 3 cf. Fischer et. al. [6]; □ — *M. psoas major*, ■ — *M. stendomandibularis*; cf. Leppelt [9]; △ and ▲ — different muscles

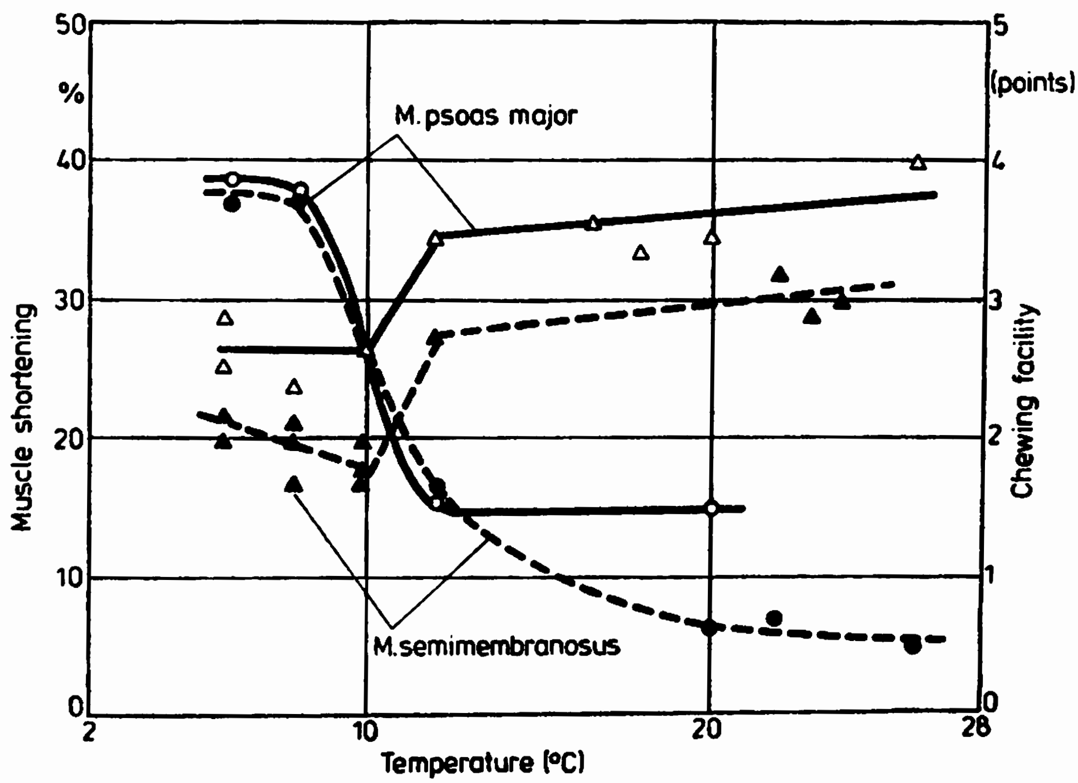

Fig. 2. Influence of cooling temperature on muscle shortening and on tenderness (chewing facility) of meat for particular muscles of cattle; ○● — muscle shortening, ▲△ — chewing facility.

for two cattle muscles. With increasing shortening of 20% to 40% the sensoric quality of the meat tenderness decreases strongly.

Cold shortening appears during the prerigor phase at quick cooling because a high muscle ATP-content of more than 50% as well as a low meat temperature below 10°C are necessary conditions [3]. To use the advantages of quick cooling or freezing of meat without the cold shortening drawbacks as mentioned before one has to reduce the muscle ATP-content to less than the half (corresponding to a pH-value of 6 within the muscle). This can be obtained by post mortem electrical stimulation of the meat.

The conduction of alternating current or pulsating direct current throught the muscle induces impulses in the nerves and thus a strong contraction of the muscle analogous to the physiological conditions. It effects the ATP- decomposition and the reduction of energy reserves, observable by a fast decrease of the muscle pH-value as shown in Fig. 3. In the given example the stimulation was performed

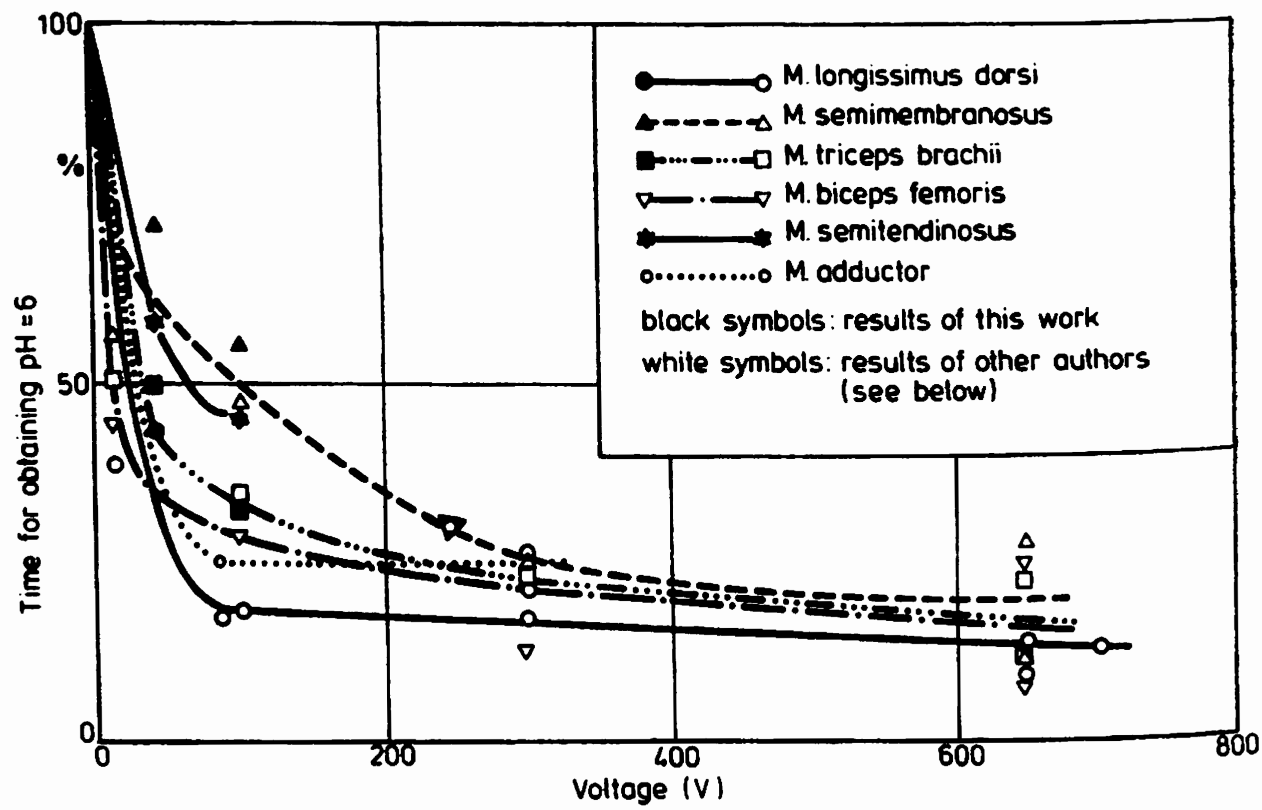

Fig. 3. Influence of stimulation voltage on the time for obtaining ph = 6 in different muscle of cattle (cooresponding time of nonstimulated reference samples equal to 100 per cent); reference data of *M. longissimus dorsi*, cf. [3, 4, 5, 11]; of *M. semimembranosus*, cf. [3], of *M. adductor*, cf. [5], of *M. triceps brachii*, cf. [3], of. *M. biceps femoris*, cf. [3, 11]

with 40 V and 100 V, respectively. In comparision with the nonstimulated sample the pH-value of 6 is obtained already after 2 to 4 hours for the stimulated sample. In general we found from our experiments that by application of electrical stimulation a value pH = 6 can be obtained already after one eight to one half of the time without stimulation and thus cold shortening will not take place during cooling of the muscle at the critical temperature of 10°C.

The inhibition of cold shortening and the strong promotion of the post mortem biochemical processes influence the meat quality advantageously. For the before mentioned muscles of catle it can be seen from Table 2 that the electrical stimulated meat exhibits on the arverage 15 per cent lower values of shearing forces already 48 hours post mortem. In dependence on the kind of

Table 2. Influence of electrical stimulation on the consistency of meat (shearing force values) of hot boned muscles of cattle in dependence on the time of cold treatment/stocking at -1°C; (given in per cent with respect to shearing force of nonstimulated samples equal to 100 per cent)

	voltage of stimulation (V)					
	40		100		150	
Time *post mortem* (h) muscles	48	216	48	216	48	216
Musculus longissimus dorsi	84	71	86	72	86	71
Muscules semimembranosus	81	64	80	78	86	75
Muscules triceps brachii	99	67	87	70	96	37
Muscules semitendinosus	74	77	77	89	79	82
Arithmetic mean	85	70	83	77	85	66

muscle and the voltage of stimulation this advantage in tenderness increases up to 23 to 34 per cent after several day stocking.

Electrical stimulation does not produce PSE-meat and has no practical influence on the water holding capacity. The drip loss is reduced for about 15 to 50 per cent in comparison with the reference samples. No influence of electrical stimulation on the colour of meat, on the aroma, on the taste, or on the microbiologic state has been found.

The efficiency of electrical stimulation is determined by the technological process of slaughter and cooling as well as the production-technological parameters of the electrical stimulation besides the biological features. Because of these manifold factors a general optimum scheme of stimulation paremeters cannot be given. As the result of our investigations of more than 30 influencing factors and including the extensive literature the following parameters for electric stimulation in practical meat processing are recommended:

1) electrical stimulation as early as possible after slaughter
2) duration of stimulation of 2 to 3 min in several intervals
3) voltage of stimulation 100 to 250 V.

In Fig. 3 it is shown that voltages of stimulation between 100 V and 250 V shorten the time to obtain pH = 6 drastically, whereas above 250 V a further increase of voltage does not yield in a significant increase of stimulation efficiency.

Frequency, shape of the d.c. pulses, and other electric parameters are of minor influence so that the usual alternating curent of 50 Hz frequency can be applied in practical meat procesing.

For meat processing of medium capacity an automatic in-line-stimulator can be applied profitably. Fig. 4 shows the diagram of a successful tested electric stimulator in practice. By using the slaughter suspension and applying an automatic adjustable puncture electrode at deeper regions of the muscles of the neck also lower voltages up to 250 V can be applied successfully in electrical stimulation.

Summarizing it follows that the application of electrical stimulation enables

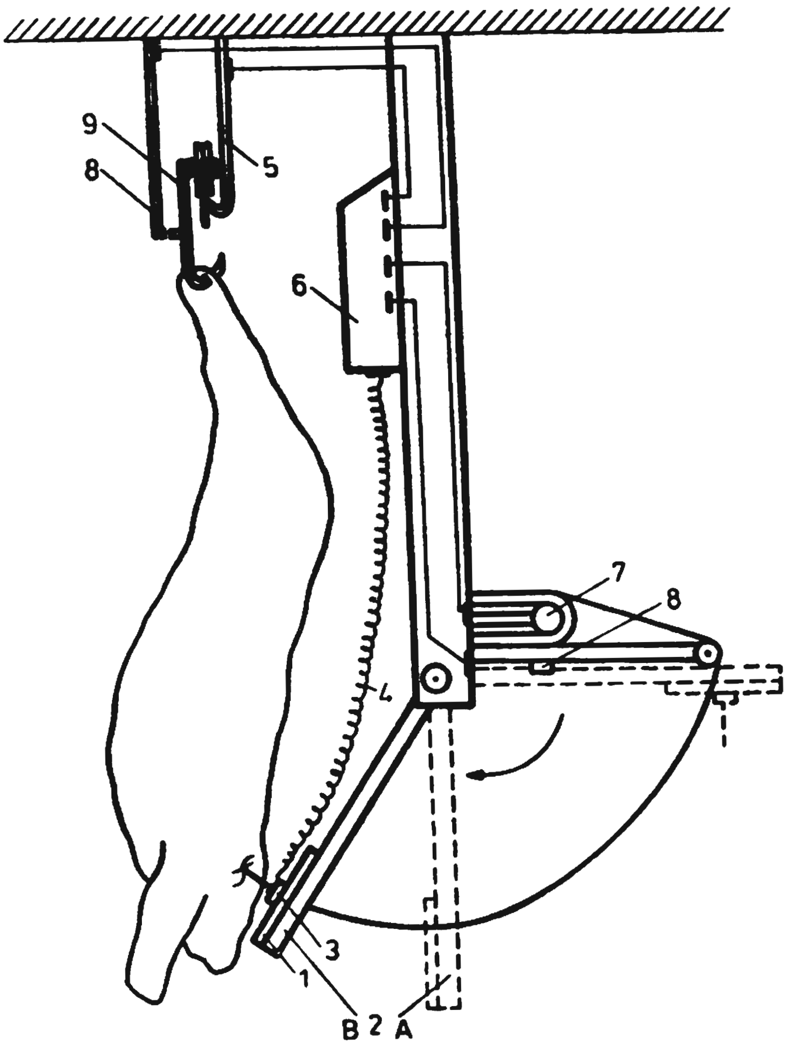

Fig. 4. Automatic in-line-stimulator according to Specht et al. [13]; 1 — gyrating mass with electrode mounting (conical fit), 2 — swinging bar at rest position (A) or at puncture position (B), 3 — electrode heat (fitting piece), 4 — current conduction cable (flexible), 5 — neutral conductor and transfor unit, 6 — transformer and timing relay, 7 — electric pulling unit (e.g. winch), 8 — electromechanical switch, 9 — automatic transport system

the useful combination of hot boning/quick cooling or freezing without drawbacks on the meat quality. The use of the presented automatic electric stimulator is profitable with respect to energy, manpower, and floor capacity at low investment.

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ELEKTROSTYMULACJA — EFEKTYWNA METODA PRODUKCJI MIĘSA O WYSOKIEJ JAKOŚCI

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Streszczenie

Jakkolwiek stosowane w nowoczesnej technologii szybkie chłodzenie i mrożenie mięsa jest korzystne z punktu widzenia higieny i ekonomiki, to następują w tych procesach również niepożądane zmiany, jak tzw. „skurcz chłodniczy" oraz twarda, łykowata konsystencja mięsa po poddaniu go obróbce termicznej.

Intensywne wykorzystanie powierzchni chłodni, jak również energii schładzania, a także transportu chłodniczego mięsa i pełnego uzyskania innych znacznych korzyści z kombinacji odkostnienia tusz „ciepłych" z szybkim chłodzeniem i zamrożeniem bez pogorszenia jakości mięsa jest możliwe przy zastosowaniu elektrostymulacji *post mortem* tusz lub półtusz, stosowane natychmiast po uboju.

W wyniku badań skurczu chłodniczego oraz elektrostymulacji tusz baranich i wołowych określono odpowiednie parametry procesu automatycznej elektrostymulacji możliwej do zastosowania na linii uboju; opracowano również stosowne urządzenia do elektrostymulacji.

Przeprowadzono systemetyczne badania nad wpływem elektrostymulacji na podstawowe parametry jakości mięsa, głównie na jego konsystencję (siła szerometryczna, długość sarkomerów, długość włókien mięśniowych), zdolność utrzymywania wody przez mięso (wyciek swobodny, wyciek pod ciśnieniem) oraz na jakość sensoryczną; ponadto przeprowadzono badania nad wpływem procesu elektrostymulacji na przebieg glikolizy w mięsie.