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THE INFLUENCE OF HIGH -VOLTAGE ELECTRICAL STIMULATION AND ANIMALS' SEX ON THE SELECTED ATTRIBUTES OF QUALITY OF COOKED BEEF HAMS PRODUCED FROM SEMITENDINOSUS MUSCLE

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ABSTRACT

This study was conducted to determine the influence of high-voltage electrical stimulation on quality of cooked beef hams produced from *semitendinosus* muscle of heifers and young bulls. Texture evaluation of hams was conducted with the universal testing machine Instron type 4301. Additionally, puncture and shear tests were performed. Six trained panelists conducted sensory analysis. The attributes evaluated were as follow: appearance, structure and consistency, taste and flavour as well as tenderness. The results of sensory examination and instrumental measurement revealed that the influence of high-voltage electrical stimulation on cooked hams depends on animals' sex. The most significant difference in quality of hams was observed between stimulated and non-stimulated hams produced from *semitendinosus* muscle of heifers. The results obtained demonstrated the effectiveness of application of own construction high-voltage device for electrical stimulation of beef carcasses in improving quality of cooked hams. The results of the study have also revealed that it is possible to increase the competitiveness of hams produced from stimulated meat as compared to hams produced from non-stimulated meat.

Key words: electrical stimulation, cooked beef hams, quality, instrumental measurement, sensory examination.

INTRODUCTION

The quality of meat and meat products depends mainly on breed, age and sex of animals, pre-slaughter handling and post slaughter treatment by application of specific technical procedures.

Nowadays, obtaining high-quality meat and meat products is one of the main tasks of modern meat science and technology. Joint efforts of scientists and technologists as well as their cooperation with cattle producers and meat processing enterprises may be beneficial if only the cooperation takes the appropriate course starting with specification of consumer requirements and ending with specification of conditions for livestock producers.

Proliferation of the method of crossbreeding dairy cows with beef bulls is one of the methods for improving the situation in the domestic meat market. Studies in that field showed a major improvement of meet from heifers and bulls produced as crossbreeds of black-white cows and Limousine bulls. That development, however, requires preparation of an appropriate breeding program, which, in turn, requires high levels of investment in purchases of breeding stock and modernization of livestock buildings [4, 5, 13].

As a consequence of low slaughter value of the domestic cattle, resulting from the fact that Poland is one of the countries where dairy cattle is the basic source of beef, low quality of meat produced, low price of that meat and limited opportunities to compete in the foreign markets, the search for new, low cost, post-slaughter methods for improvement of meat and meat products is the best solution in the current situation [11, 13]. Electrical stimulation is one of such technical procedures. It is based on treatment of the meat of carcasses (half-carcasses) with electric current during the first hour after slaughter. Application of electrical stimulation improves quality features of meat and meat products such as tenderness, colour and palatability [7, 9, 16].

OBJECTIVE

The objective of the study was to determine the influence of own construction high-voltage electrical stimulation device on the quality of cooked beef hams, produced from *semitendinosus* muscle of young stock under industrial conditions, depending on sex of the animals.

MATERIALS AND METHODS

Beef (*semitendinosus* muscle) from 8 heifers and 8 young bulls of black-white breed, aged 18 months was used in the experiment. The animals were slaughtered after ca. 1 hour rest in the lairage. Electrical stimulation of left half-carcasses was conducted with own construction electric stimulation device for beef half-carcasses (the device was implemented in Ostrołęka Meat Plant S.A. in Ostrołęka. It was awarded the bronze medal at the 45th International Exhibition of Inventions and Innovations "Brussels Eureka 96") [15] applying current (330V, 17 Hz, 0.9 pulse duty factor) for 120 seconds. Right half-carcasses were kept as controls. About 24 hours after stunning, the muscles were trimmed from half carcasses and divided into pieces weighting about 1000 g each. Thereafter beef was subjected to pumping, tumbling, smoking, cooking and cooling according to the technical process applied at Ostrołęka Meat Plant S.A in Ostrołęka.

Texture evaluation of hams was conducted with the universal testing machine Instron type 4301. Shear test was conducted with the universal meat Shear Warner-Bratzler (type 2830-013) device. The samples of hams were rectangular prisms (10x10x30mm) cut parallel to the orientation of muscle fibres. The puncture test was conducted with flat plunger 12.6 mm in diameter. The slices of ham (30x30x10mm), cut also parallel to the orientation of muscle fibres, were put onto a metal support plate with a hole with diameter of 15.3 mm. In all performed tests the speed of working part was set to the same level (50 mm/min). Measurements conducted in the experiment were as follows: the maximum shear and puncture forces, sample displacement at maximum shear and puncture forces, energy at 50% deformation for the shear and puncture forces and maximum shear and puncture forces at 50% deformation of the sample. The results of the measurements were computer analysed using Instron IX Series software, Version 7, 43 [2, 3].

Six trained panellists conducted sensory examination. The following attributes of beef hams were examined: appearance, including meat colour, structure and consistency, taste and flavour as well as tenderness, using the 1-5 point scale according to the PN A 82007 [6].

Statistical analysis of the results obtained was carried out using the analysis of variance. The average values were compared by applying Dunkan and Student-Newman-Keuls test (Q-SNK) [10].

RESULTS AND DISCUSSION

The results of instrumental evaluation revealed significant influence of electrical stimulation on decreasing the mechanical resistance of cooked hams produced from young bull and heifer meat, as if the decrease of values of maximum shear and puncture forces, shear and puncture forces at 50% deformation of sample and energy at 50% deformation for shear and puncture forces was observed for hams from stimulated meat compared to hams from non-stimulated meat. Maximum shear force values for hams derived from stimulated and non-stimulated meat of heifers as well as maximum puncture values from young bulls were significantly different (25 and 23% respectively). Values of maximum shear and puncture forces at 50% deformation and value of energy used to puncture the hams sample from heifer and young bull meat differed in 20%. Lowest differences (9-12%) were observed between the values of max. puncture forces for hams produced from heifers, maximum shear force for hams from young bulls and the amount of energy used to puncture hams produced from heifer and young bull meat. Influence of electrical stimulation on measurement of hams sample displacement at maximum shear forces was not noticed. (Table 1, 2).

Table 1. The results of instrumental measurements of beef hams – shear test

Experimental group	Heifers, n = 8				Young bulls, n = 8			
	S		K		S		K	
Statistical measure	$\bar{x}$	V (%)	$\bar{x}$	V (%)	$\bar{x}$	V (%)	$\bar{x}$	V (%)
$F_{c\ max}$ [N]	30.00^a	8.49	40.00^b	10.62	30.00^a	13.22	34.00^b	9.73
D_c [mm]	15.79^a	13.77	15.76^a	24.49	16.60^a	8.47	15.86^a	18.17
F_c [N]	23.00^a	9.65	29.00^b	18.40	23.00^a	11.43	28.00^b	8.96
E_c [J]	0.42^a	7.36	0.48^b	10.64	0.41^a	10.78	0.45^a	6.25

S - stimulated samples, K - control samples, $\bar{x}$ – average value, V – coefficient of variation, $F_{c\ max}$ - maximum shear force, D_c –displacement at maximum shear force, F_c – shear force at 50 % of deformation, E_c – energy at 50 % of deformation, at shear test, $F_{p\ max}$ maximum puncture force, D_p – displacement at maximum puncture force; F_p – puncture force at 50 % of deformation, E_p – energy at 50 % of deformation at puncture test, $^{a, b}$ - average values of stimulated and non-stimulated samples with different superscripts in verses are significantly different (P≤0.05), n – the number of cattle.

Table 2. The results of instrumental measurements of beef hams – puncture test

Experimental group	Heifers, n = 8				Young bulls, n = 8			
	S		K		S		K	
Statistical measure	$\bar{x}$	V (%)	$\bar{x}$	V (%)	$\bar{x}$	V (%)	$\bar{x}$	V (%)
$F_{p\ max}$ [N]	48.00^a	16.31	53.00^b	12.46	41.00^a	24.15	53.00^b	11.08
D_p [mm]	7.51^a	13.76	6.24^b	12.45	6.93^a	18.36	7.77^a	13.64
F_p [N]	7.00^a	30.94	9.00^a	41.22	8.00^a	69.18	10.00^a	38.30
E_p [J]	0.33^a	11.62	0.42^b	13.71	0.36^a	13.25	0.45^b	11.85

The results of sensory examination revealed that the effect of electrical stimulation on improving the quality of hams from heifer and young bull meat was differentiated and depended on the attribute examined. The highest final score (4.94 points) for the examined attributes was obtained by hams produced from stimulated heifer meat (Fig. 1). All evaluated attributes of those hams scored higher compared to non-stimulated heifer meat as well as stimulated and non-stimulated young bull meat (Fig. 2). The highest difference in the score (26%) for hams produced from stimulated and non-stimulated heifer meat related to tenderness. The final score for hams produced from stimulated young bull meat was only 1% higher than the final score value for hams produced from non-stimulated young bull meat. For all examined attributes of hams produced from young bull meat, tenderness obtained the highest final score. The scores for tenderness of hams from stimulated young bull meat were about 6% higher than the scores for hams from non-stimulated young bull meat (Figures 1, 2).

Fig. 1. The results of sensory examination of beef hams produced from heifers meat

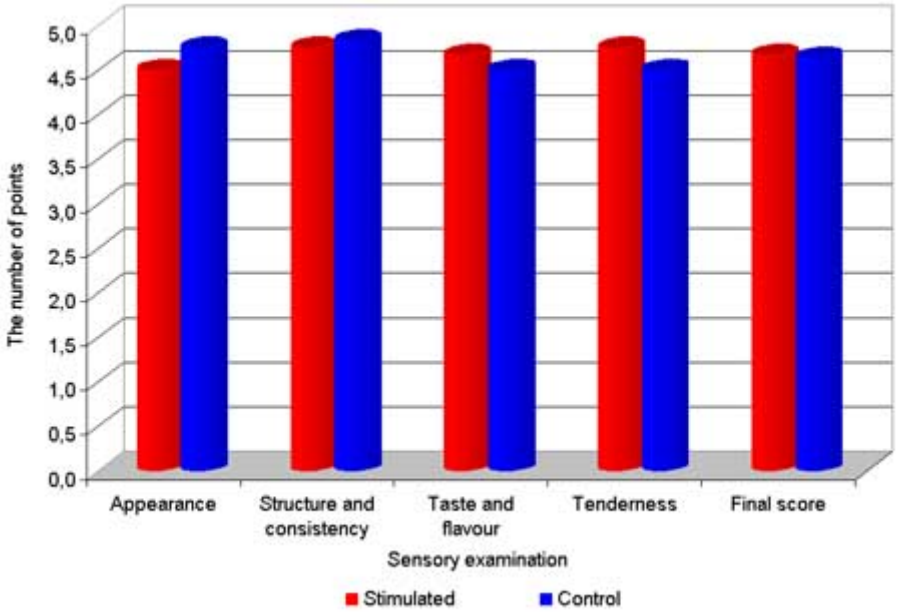
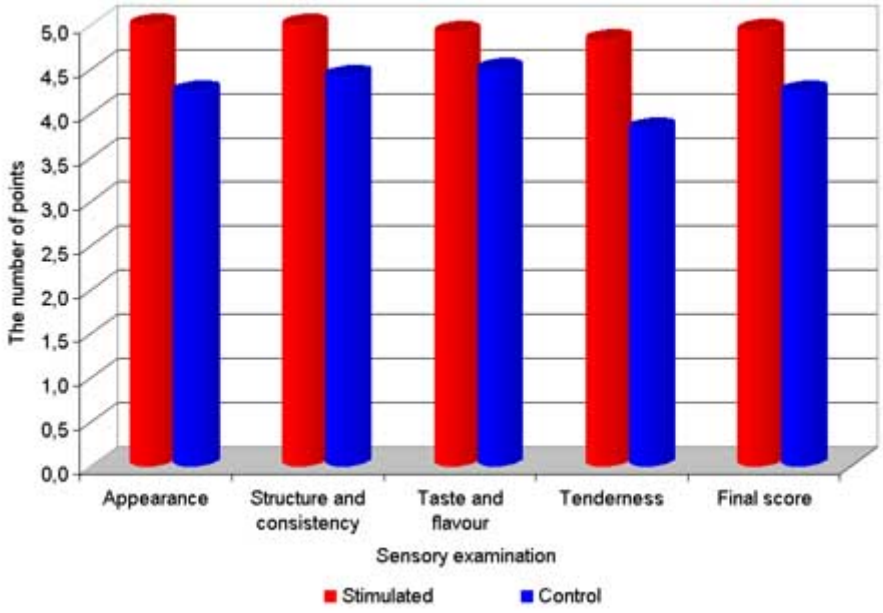


Fig. 2. The results of sensory examination of beef hams produced from young bulls meat



Differentiated influence of electric stimulation on quality of hams produced from meat of heifers and young bulls is probably related to the different level of stress to animals during pre-slaughter handling. Short rest time (ca. 1 h) at lairage had a positive influence on the quality of hams produced from the meat of young bulls while the influence on the quality of hams produced from the meat of heifers was negative. That is indicated by higher scores of hams produced from the non-stimulated meat of young bulls than those obtained by hams produced also from non-stimulated meat of heifers [12, 14].

Differences in scores for tenderness in sensory examination of hams produced from stimulated and non-stimulated heifer meat are similar to those observed between maximum shear force and maximum shear and puncture forces at 50% deformation of sample. Instrumental measurement did not reflect the observed differences (6%) in the final score for tenderness of hams produced from stimulated and non-stimulated young bull meat. Values of energy used to puncture the sample (9%) and maximum shear force (12%) are closest to the value of final score for tenderness. Differences between respective values of puncture test are higher and they are estimated as 20% and 23% respectively.

On the basis of the sensory hams quality examination results it was established that hams produced from non-stimulated young bull meat scored better for tenderness and in total than hams produced from non-stimulated heifer meat. Still, hams from heifer meat obtained the highest final score for tenderness and other attributes examined. This finding suggests that electrical stimulation may be used not only to produce beef of uniform tenderness [1, 8] but to improve the quality of hams produced form *semitendinosus* muscle of young stock, which is expressed by higher scores for individual attributes as well as the final scores from the sensory examination. The influence of stimulation is increasingly well visible when quality of meat that was subjected to stimulation is low.

The results of the sensory examination and findings presented in the paper confirm the results obtained in previous researches on this subject performed by the authors [17]. The earlier studies revealed that cooked hams produced from *semimembranosus* muscle of heifers slaughtered after 1 hour rest and then electrically stimulated, received scored lower for tenderness and their final score (sensory evaluation) was lower compared to results of sensory evaluation obtained by hams produced from heifer *semitendinosus* muscle. Higher final score of hams produced from the *semitendinosus* muscle results from more homogenous chemical composition, less intensive colour and significantly better tenderness obtained by the hams after electrical stimulation.

CONCLUSIONS

1. The results obtained proved a positive influence of applying the own construction device for electric stimulation of beef carcasses upon quality improvement of cooked beef hams produced from *semitendinosus* muscle of young stock.
2. The results of instrumental and sensory evaluation showed a differentiated influence of high voltage electrical stimulation upon the quality of cooked hams depending on the sex of animals. The highest differences in quality of hams produced from *semitendinosus* muscle from stimulated and non-stimulated half-carcasses were recorded in case of heifers.
3. Better quality of hams produced from stimulated *semitendinosus* muscle of heifers compared to quality of hams produced from stimulated and non-stimulated *semimembranosus* muscle increases the range of possibilities for beef ham production.

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