INFLUENCE OF HIGH-VOLTAGE ELECTRICAL STIMULATION, AGE AND SEX ON QUALITY OF BEEF HAMS

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Key words: electrical stimulation, texture, beef hams, instrumental measurements, sensory examination

Background

Electrical stimulation is one of commonly used technological procedure which improves the quality of beef mainly its tenderness, colour and palatability. This method is based on influence of electric current imitating nerve impulses on muscle tissue (carcass, half carcass) during the first hour after slaughter. The applying of the electrical stimulation results in acceleration of post-slaughter changes and consequently in rapid fall of pH. This rapid fall of pH produces disruption of lysosome membranes and releases the enzymes. Under the conditions of low pH and high temperature of muscles, lysosome enzymes are able to degradation of proteins which are responsible for tenderness of beef and its products (Mikami et al. 1991, Dransfield 1992).

Objective

The objective of this study was to determine the influence of electrical stimulation, age and sex on texture of beef hams.

Methods

The experimental material was beef (m. semimembranosus) derived from heifers at about 18 months (n = 8), young bulls 18 months (n = 8) and cows 8 years old (n = 8). The cattle were slaughtered after 12 hours' rest. Electrical stimulation of left half-carcass was conduced with electric current (350 V, 17 Hz, 0.9 pulse duty factor) during 120 sec. The right half carcass was the control sample. About 24 hours after stunning, the muscles were trimmed from half carcasses and divided into pieces at about 1000 g each. Then beef was applied to pumping, tumbling, smoking, cooking and cooling according to the technology of Meat Plant Ostrołęka S.A. in Ostrołęka. Texture evaluation of hams was conducted with the universal testing machine Instron, type 4301. In the shear test the samples were cut by a 1 mm thick shear blade of a Warner-Bratzler meat Shear (type 2830-0130) device. The samples of hams were rectangular prisms (10x10x30 mm) cut paralelly to the orientation of muscle fibres. The puncture test was conducted with a flat plunger 12.6 mm in diameter. The slice of ham (30x30x10 mm) was placed on a metal support plate with a hole with diameter of 15.3 mm. The speed of working parts in these tests was at the same level of 50 mm/min. The following measurements were conducted: the maximum shear and puncture forces, displacement at the maximum shear and puncture forces, energy at 50 % of deformation for the shear and puncture tests. Tests were analysed by a computer (software Instron IX Series, Version 7.43). Sensory analysis was conducted by six trained panellists. The following attributes of beef were tested: appearance, structure and consistency, tenderness, taste and smell with 1-5 point scale according to PN A 82007 (1996). Because of the necessity to compare the results of sensory examination with the results of instrumental measurements, the additional tenderness evaluation was carried out. Colour of hams was included in the appearance assessment. Statistic analysis of the results was carried out with an analysis of variance. The average values were compared using the Student's t-test (SAS/STAT, 1991).

Results and discussion

The results of instrumental measurements revealed distinct influence of high-voltage electrical stimulation on the decreasing of the mechanic resistance of beef hams independently from sex and age of cattle (tab. 1). The results of shear test showed that the biggest significant differences ($P<0.05$) between maximum shear force values of stimulated samples and maximum shear force values of control samples were obtained for hams produced from meat of heifers. The biggest significant differences ($P<0.05$) between the values of energy at 50% of deformation were obtained for hams produced from meat of cows. Significant differences between the displacement of meat samples at maximum shear force were obtained only for hams produced from meat of cows

Table 1

Influence of electrical stimulation, age and sex on chosen attributes of beef hams texture - the shear test

Experimental group	Heifers				Young bulls				Cows			
	S		K		S		K		S		K	
Statistical measure	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]
F_s [N]	36.00^a	7.59	41.00^b	16.96	37.00^a	15.56	37.00^a	10.57	35.00^a	17.27	39.00^b	15.29
D_s [mm]	17.49^a	12.02	17.82^a	7.77	16.26^a	16.48	15.06^a	6.01	20.10^a	4.13	16.26^b	22.22
E_s (J)	0.466^a	5.69	0.484^a	6.71	0.463^a	11.07	0.472^a	8.84	0.431^a	8.01	0.470^b	9.05
pH_{24}	5.57		5.66		5.66		5.77		5.48		5.65	

Explanation of the tabs: $\bar{x}$ - average value, V - coefficient of variation, S – stimulated samples, K – non-stimulated samples, F_s – maximum shear force, D_s - displacement at maximum shear force, E_s - energy at 50 % of deformation in the shear test, F_p – maximum puncture force, D_p - displacement at maximum puncture force, E_p - energy at 50 % of deformation in the puncture test, pH_{24} – pH value 24 h after slaughter, $^{a, b}$ – average values of stimulated and non-stimulated samples with different superscripts are statistically significant ($P<0.05$).

The results of puncture test showed that the biggest significant differences ($P<0.05$) between values of maximum puncture forces of stimulated and non-stimulated samples were obtained for hams produced from meat of cows. The lower differences between these values were obtained for hams produced from meat of heifers and young bulls. Similarly to the shear test, the biggest significant differences ($P<0.05$) between the amount of energy at 50% of deformation were obtained for hams produced from meat of cows. Smaller significant differences ($P<0.05$) were observed for hams produced from meat of heifers and young bulls. Significant differences ($P<0.05$) between the displacement of stimulated samples and non-stimulated ones were obtained for hams produced from heifers (tab. 2).

Table 2

Influence of electrical stimulation, age and sex on chosen attributes of beef hams texture - puncture test

Experimental group	Heifers				Young bulls				Cows			
	S		K		S		K		S		K	
Statistical measure	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]
F_p [N]	48.00^a	13.58	58.00^b	12.53	42.00^a	18.67	47.00^b	15.30	43.00^a	17.27	56.00^b	12.67
D_p [mm]	5.37^a	21.19	7.47^b	12.55	7.88^a	19.39	8.61^a	9.42	8.12^a	18.48	8.10^a	18.59
E_p [J]	0.400^a	11.16	0.510^b	11.72	0.384^a	21.63	0.459^b	16.97	0.413^a	25.18	0.540^b	17.48

Table 3

Influence of electrical stimulation, age and sex on chosen sensory attributes of beef hams

Experimental group	Heifers				Young bulls				Cows			
	S		K		S		K		S		K	
Statistical measure	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]	$\bar{x}$	V [%]
Appearance	5.00	0.00	4.33	9.42	4.92	4.15	3.92	14.92	4.58	8.20	4.08	16.27
Structure and consistency	4.83	8.45	4.33	9.42	5.00	0.00	3.92	14.92	4.58	10.72	3.75	20.22
Tenderness	4.67	17.49	3.83	10.65	5.00	0.00	3.75	11.15	4.92	4.15	3.92	16.97
Taste and smell	4.75	8.81	4.42	8.52	4.92	4.15	4.58	8.21	4.67	8.75	4.42	11.13
Final score	**4.81^a**	**8.69**	**4.23^b**	**9.50**	**4.96^a**	**2.07**	**4.04^b**	**12.3**	**4.69^a**	**7.95**	**4.04^b**	**16.15**

The results of sensory examination indicate that the hams produced from beef subjected to electrical stimulation are of much better quality than hams produced from non-stimulated beef, independently the sex and age (tab. 3). The hams produced from stimulated meat of young bulls obtained the best tenderness as well as the highest final score of the examined attributes. The hams produced from meat of cows obtained the smallest number of scores. Though the final score for hams produced from stimulated meat of cows was the lowest of all stimulated hams, it was the biggest in comparison with the hams produced from non-stimulated meat (heifers, young bulls, cows). The results obtained acknowledge the literature that the quality of meat products, especially the texture, is very difficult to define uniquely by means of one or a few parameters. Taking all into consideration, the assessment of quality of hams produced from beef applied to electrical stimulation was carried out by both the instrumental measurements and sensory examination (Brady and Hunecke 1985, Beilken et al. 1991). Additionally, considering the sex and age of the cattle, one obtained more objective assessment of influence of electrical stimulation on the improvement of texture of beef hams.

Conclusions

1. The lower values of maximum shear and puncture forces for electrically simulated samples than the maximum values of shear and puncture forces for control samples give the evidence that beef hams applied to electrical stimulation are less mechanically resistant and that their tenderness is better than tenderness of hams produced from non–simulated beef. This is supported also by the measurements of energy at 50% of deformation in shear and puncture tests.
2. Higher final scores for hams produced from meat of cows applied to electrical stimulation than the final scores of hams produced from non-stimulated meat of heifers and young bulls allow to produce beef hams of good quality independently from age and sex of the cattle.
3. The results of sensory examination complete and support the results of instrumental measurements and justify the applying of the high-voltage electrical stimulation to improve the quality of beef hams.

References

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