THE FORECASTING OF BEEF QUALITY APPLIED TO HIGH-VOLTAGE ELECTRICAL STIMULATION DIRECTLY AFTER SLAUGHTER

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Background

The way of conducting cattle before slaughter, the applying of suitable technological procedures as well as the choice of cooling methods have decisive effect on beef quality. Stress and fatigue of the animals before slaughter diminish the content of glycogen in muscles, the result of which is insufficient amount of lactic acid (low meat acidification),which consequently does not guarantee good quality and durability of beef. The range of pH values, as a result of post-mortem glycolysis 48 hours after slaughter, determines the quality of meat and its usefulness to cooking. The pH of standard bright colour meat varies from 5.4 to 5.8 whereas pH for defective meat, type DFD, is higher than 6.2. Meat of pH within the range from 5.8 to 6.2 characterises with indirect quality (Fjelkner-Modig and Rudérus 1983, Pisula 1996).

Long period of beef ripening, 14 days under cooling conditions, makes the scientists take the research aiming to its shortening and indicates on possibilities to determine final pH value before the beginning of cooling process. Electrical stimulation is one of commonly used technological procedure accelerating the process of post-mortem changes. This process is characterised with quick fall of pH (from 0.3 to 0.7 units directly after applying electrical stimulation). As a result, the improvement of beef tenderness, colour and flavour appears (Kastner et al. 1993, Polidori et al. 1996, Kornacki et al. 1998).

Objective

The objective of this study was to determine the rate of pH changes, 48 h after slaughter, and to indicate the possibilities of its forecasting, considering the influence of before-slaughter factors and electrical stimulation which determine the quality of beef.

Methods

Heifers aged about 18 months (n=28), young bulls aged about 18 months (n=61), cows aged from 5 to 10 years (n=14) and bulls aged from 5 to 10 years (n=20) were the experimental material. Cattle applied to slaughter were characterised with different degree of fatigue and stress. Electrical stimulation was conducted with alternating current(effective voltage 330V, frequencies 17 Hz, pulse duty factor 0.9, rectangular impulses) after flaying and evisceration. Following measurements have been taken: pH of *longissimus dorsi* directly before electrical stimulation (about 40 min after stunning - 2/3 h) and during the process of storage about 2, 6, 24, 48 h after stunning with pH-meter HI 8313C equipped in dagger FC 200 electrode. Because the statistical analysis of the results did not show the essential differences between the average values of pH after 24 and 48 h after stunning, the final value of pH 24 h after stunning was accepted and given in tables. Voltage on electrodes after about 20 s from the beginning of electrical stimulation was measured with volt-meter type LE-3. Intensity of current after about 5 s from the beginning of the electrical stimulation (initial value - I_p) and after 3 s before the end of electrical stimulation (final value - I_k) was measured with ammeter LE-3P. Statistical analysis of the results obtained were conducted on the basis of analysis of variance for 1, 2 and 3 factor experiences: cross-shaped, orthogonal and non-orthogonal. To compare the average values one used the Dunkan test and q-SNK test. To determine the dependence between parameters of current and pH, one counted correlation and linear regression (SAS INSTITUTE, Inc. 1991, Taylor 1995).

Results and discussion

Analysis of correlation of pH of *longissimus dorsi* muscle of heifers, young bulls, bulls and cows in function of changes of pH measured about 40 min after stunning as well as the changes of current intensity flowing through each carcass showed that at significance level ($P<0.01$) there are dependencies between pH measured after 2, 6 and 24 h after stunning in function of pH value measured 40 min after stunning and the final value of current intensity.

Table 1

Regression analysis of pH value after electrical stimulation in function of pH measured directly before electrical stimulation – 2/3 h after stunning

Statistical measure		$\bar{x}$	V (%)	r	p	Regression equation
Time	2/3	6.90	1.14	----	----	------
after stunning (h),	2	6.21	4.27	- 0.694**	0.000	$pH_2 = 22.390 - 2.343\ pH_{2/3}$
pH	6	6.08	5.66	- 0.713**	0.000	$pH_6 = 27.669 - 3.127\ pH_{2/3}$
	24	5.99	6.47	- 0.823**	0.000	$pH_{24} = 34.029 - 4.062\ pH_{2/3}$

The equations presented in table 1 allow, knowing the pH value 40 min after stunning, to count pH which will be obtained by muscles after 2, 6 and 24 hours after stunning. For average value $pH_{2/3}$ 6.90, pH_2 will be 6.22, pH_6 will be 6.09, whereas pH_{24} will be 6.00. For the lowest $pH_{2/3}$ (6.76), pH after 2, 6 and 24 h after stunning will be appropriately 6.55; 6.53; 6.57. For the highest $pH_{2/3}$ (7.01), pH after 2, 6 and 24 h after stunning will be 5.97; 5.75; 5.55. The equations presented in table 2 allow, knowing the final value of current intensity flowing through beef carcasses, to count pH values which examined muscles will obtain 2, 6 and 24 h after stunning.

Table 2

Regression analysis of pH value after electrical stimulation in function of final current intensity (I_k) flowing through carcasses of heifers, young bulls, bulls and cows during electrical stimulation

Statistical measure		$\bar{x}$	V (%)	r	p	Regression equation
I_k (A)		1.691	16.12			
Time	2/3	6.90	1.14	----	----	------
after stunning (h),	2	6.21	4.27	0.495**	0.000	$pH_2 = 5.400 + 0.482\ I_k$
pH	6	6.08	5.66	0.571**	0.000	$pH_6 = 4.865 + 0.721\ I_k$
	24	5.99	6.47	0.675**	0.000	$pH_{24} = 4.364 + 0.960\ I_k$

For average value of current intensity 1.691, pH_2 will be 6.21, pH_6 will be 6.08 whereas pH_{24} will reach 5.99. For the lowest value of current intensity (1.25 A), pH values after 2, 6 and 24 h after stunning will be 6.00; 5.77; 5.56. For the highest value of current intensity (2.25 A), pH value 2, 6 and 24 h after stunning will be appropriately: 6.48; 6.49 and 6.52. On the basis of $pH_{2/3}$ as well as on the final value of current intensity one allow, as previously, to count pH values for muscles examined after 2, 6 and 24 h after stunning according to the equations presented in table 3.

Table 3

Regression analysis of pH value after electrical stimulation in function of pH measured directly before electrical stimulation (2/3 h after stunning) as well as in function of final current intensity (I_k) flowing through carcasses of heifers, young bulls, bulls and cows during electrical stimulation

Statistical measure		$\bar{x}$	V (%)	R^2	p	Regression equation
I_k (A)		1.691	16.12			
Time	2/3	6.90	1.14	----	----	------
after stunning (h),	2	6.21	4.27	0.505**	0.000	$pH_2 = 19.865 - 2.021\ pH_{2/3} + 0.1778\ I_k$
pH	6	6.08	5.66	0.563**	0.000	$pH_6 = 22.767 - 2.501\ pH_{2/3} + 0.3451\ I_k$
	24	5.99	6.47	0.760**	0.000	$pH_{24} = 27.217 - 3.193\ pH_{2/3} + 0.4796\ I_k$

Explanation of tabs: $\bar{x}$ - average pH value, V - coefficient of variation, r - correlation coefficient, R^2 - multiple correlation coefficient, p - significance level - calculated, $pH_{2/3}$ - pH value measured before electrical stimulation, pH_2, pH_6, pH_{24}, - pH value 2, 6 and 24 h after stunning, I_k – final value of current intensity, ** - correlation significance, $P<0.01$.

For average values $pH_{2/3}$ 6.90 and I_k = 1.691 pH_2 will reach 6.22, pH_6 will be 6.09 whereas pH_{24} will be 6.00. For the lowest $pH_{2/3}$ (6.76) and the highest I_k = 2.25A, pH 2, 6 and 24 h after stunning will be accordingly 6.60; 6.64; 6.71. For the highest $pH_{2/3}$ (7.01) and the lowest I_k = 1.25 A, pH 2, 6 and 24 h after stunning will be accordingly: 5.92; 5.67; 5.44. On the basis of the results obtained one ascertained that the extreme final $pH_{2,6,24}$, were obtained for extreme values $pH_{2/3}$ and I_k, independently on quantity measured. In the muscles of carcasses in which $pH_{2/3}$ were the lowest, the highest values of current intensities were observed. The results obtained also confirm that the low pH, 40 min after stunning, as a result of fatigue and stress of the animal, determine the prognosis that meat type DFD will be obtained. Statistical analysis of the results did not show the dependence between voltage and pH values 2, 6 and 24 h after stunning.

Conclusions

Dependencies between pH 2, 6 and 24 h after stunning in function of pH 2/3 h after stunning and the final value of current intensity give the possibility to determine the pH value in the presented time range directly after electrical stimulation. This will permit to:

- determine the time after which stimulated meat will enter post mortem stage, rigor mortis, (pH 5.9) as well as to apply the proper cooling system in order to avoid the cold shortening meat effect,
- select meat accordingly to the rate of pH changes as well as to the final pH value 24 h after stunning,
- indicate DFD meat before the beginning of the cooling process,
- select meat automatically in accordance with its quality.

References

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