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Practical evaluation of method of porker meat classification based on criteria pH_1 and R_1

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ABSTRACT

Examinations covered 1176 porkers of Polish Landrace breed. The fresh meat quality was evaluated on the basis of several physicochemical characteristics, determined in the muscle tissue of *m. longissimus dorsi*, 45 min and 24 h after slaughter. Polymorphism of blood proteins Phi, Po2 and Pgd, determined by genes linked to halothane-sensitivity locus Hal, was tested electrophoreticaly. The frequency of occurence of Phi^B-$Po2^S$-Pgd^A (BSA) and Phi^B-$Po2^S$-Pgd^B (BSB) haplotypes in respective classes of porkers whose meat was classified as PSE, partly PSE, normal and DFD, confirmed that the most useful method of classification of meat in Polish Landrace breed is method based on the following limit values of pH_1 and R_1: PSE ($pH_1 < 6.0$; $R_1 \geq 1.09$), partly PSE ($pH_1 < 6.0$; $R_1 < 1.09$) normal ($pH_1 \geq 6.0$; $R_1 < 1.09$), DFD ($pH_1 \geq 6.0$; $R_1 \geq 1.09$).

The diagnostics value of pH_1 and R_1 used for fresh meat quality evaluation was determined on the basis of coefficient of canonical correlation C^R. The correctness of method of meat quality evaluation was verified on the basis of quality of ham prepared using *m. semimembranosus* (I group-100 pigs) and *m. semimembranosus, m. quadriceps femoris, m. biceps femoris* (II group-104 pigs). The verification of correctness of the method used confirmed that parameters pH_1 and R_1 determined in *m. longissimus dorsi* at 45 min post mortem allow to prognose the quality of ham conserved.

KEY WORDS: meat quality evaluation, methods, pigs

INTRODUCTION

Many methods have been presented in distinguishing meat with PSE and DFD. Despite the long-term investigation on the methods of meat classification, no criterion or criteria have been found allowing explicit and quick deter-

mination of faulty meat resulting from genetic and physiological traits of an animal, related to a reaction of an organism to stressing factors.

The most frequent criteria of meat classification are:

– pH values determined in the MLD 45 min *post mortem* (pH_1) allowing detection of PSE meat (Briskey and Wismer-Pedersen, 1961);

– pH_{45} and pH_{24} (24 h *post mortem*) values, used to detect three clasess of meat: PSE, normal, DFD (Scheper, 1976; Wirth, 1985) or five clasess: PSE, partly PSE, normal, partly DFD, DFD (Kortz, 1986);

– pH values and IMP/ATP nucleotide ratio (R1) determined in the MLD 45 min *post mortem*, allowing to distinguish faulty PSE and DFD meat from normal (Honikel and Fischer, 1977; Koćwin-Podsiadła and Chmura-Janowiak, 1988; Koćwin-Podsiadła et al., 1992; Koćwin-Podsiadła and Kurył, 1992); – histochemical and histological traits of muscle tissue (Kłosowska et al., 1984).

In many countries pigs are selected on the basis of the halothane test which enables elimination of individuals with genetically conditioned defect of tissue membranes (homozygotes of Hal^n allele determining susceptibility to halothane). Since, as it has been explicity found (Archibald and Imlah, 1985), meat revealing PSE and DFD is most often identified in halothane-susceptible individuals, the elimination of Hal^n allele from a population is accompanied by a decrease in the frequency of occurence of faulty meat (Archibald and Imlah, 1985; Vögeli et al., 1984, 1985). Hal^n gene is linked with Phi, Po2 and Pgd genes controlling polymorphism of phosphohexose isomerase of blood erythrocytes postalbumin-2 in blood serum, 6-phosphogluconate dehydrogenase.

This study was aimed at evaluating the criteria pH_1 and R_1 used for porcine classification as well as its verification on the basis of physicochemical characteristics of fresh meat and quality of conserved ham.

MATERIAL AND METHODS

The studies were performed on the material comprising of 1176 porkers of Polish Landrace breed. The characteristics of meat quality were measured in *m. longissimus dorsi* at the last rib by the following methods:

– pH_1 value was measured at 45 min and pH_{24} at 24 h *post mortem* in muscle homogenate (10 g of muscle was homogenized with 10 ml of distilled water),

– the nucleotide ratio IMP/ATP was measured according to Honikel and Fisher (1977): R_1 at 45 min and R_{24} at 24 h after slaughter,

– water-holding capacity (HWC) was determined according to Grau and Hamm (1952),

– drip loss was tested by the method of Prange et al. (1977),

– the colour lightness was measured at 24 h after slaughter,
– activity of LDH and CPK was measured according to routine methods.

The limit values of pH_1 and R_1 for differentiation between normal, PSE, partly PSE and DFD meat have been applied as follows:

class of meat	pH_1	R_1
normal	$\geqslant 6.0$	< 1.09
PSE	< 6.0	$\geqslant 1.09$
partly PSE	< 6.0	< 1.09
DFD	$\geqslant 6.0$	$\geqslant 1.09$

according to Honikel and Fischer (1977) in modification by Koćwin-Podsiadła et al. (1988).

The muscle *m. semimembranosus* was used for preparation ham of group I (100 pigs) and muscles, *m. semimembranosus, m. biceps femoris* and *m. quadriceps femoris* for preparation of hams of group II (104 pigs). These two groups of ham were made to check the possibility of prognosis of conserved ham quality on the basis of evaluation of *m. longissimus dorsi* characteristics.

The quality of ham of both groups, I and II, was evaluated on the basis of organoleptic parameters as follows: consistence, slice compactness (0-5 points) and gelatine content. The diagnostic value of pH_1 and R_1 criteria for fresh meat quality evaluation was determined on the basis of canonical correlation coefficient C_R. This analysis was performed on two groups of porkers: group I – 148 pigs, and group II – 261 pigs (according to Harris, 1975; Krzyśko and Ratajczyk, 1978).

Polymorphism of Phi, Po2 and Pgd blood proteins, determined by genes linked to halothane-sensitivity gene Hal^n, was tested according to Gahne and Juneja (1985). In each class of fresh meat, selected on the basis of the above discribed methods, the analysis of Phi– Po2-Pgd haplotypes (the appropriate system of alleles in relation to these *loci*) distribution was performed.

The frequency of occurence of Phi-Po2-Pgd haplotypes within meat classes was expressed as a per cent ratio. The significance of strenght association between occurence of different Phi-Po2-Pgd haplotypes and meat quality was evaluated on the basis of coefficient of linkage disequilibrum D, calculated according to Vögeli and Schwörer (1982).

RESULTS AND DISCUSSION

The tested pigs were divided into four groups: normal, PSE, partly PSE and DFD, on the basis of assessment of their meat quality. Phi-Po2-Pgd haplotypes have been defined for 352 individuals – triple homozygous or heterozygous in

TABLE 1

Phi-Po2-Pgd haplotypes i Polish Landrace pigd with normal, partly PSE, PSE and DTD meat

Phi-Po2-Pg Haplotypes	Frequency of haplotypes, % classes of meat quality			
	normal	partly PSE	PSE	DFD
AFA	6.3	3.1	2.6	1.1
AFB	1.1	–	–	3.3
ASA	0.4	3.1	1.3	1.1
ASB	0.8	–	–	–
BFA	45.4	35.9	30.3	33.3
BFB	29.1	29.7	15.8	30.0
BSA	6.1	10.9	26.3	16.7
BSB	10.8	17.2	23.7	14.4

TABLE 2

Linkage disequilibrum (D), standarized linkage disequilibrum ($D_S = F/D_{max}$), significance of D coefficient (k) between genetic variants of Phi, Po2, Pgd and meat quality

Group	Phi-Po2-Pg	meat	χ^2	D	D_S	k
A	AFA	normal	5.66^{xx}	0.0234	0.59	4.97
		PSE	0.99	-0.0200	0.13	1.33
		DFD	3.26	-0.0420	0.29	3.59
B	BFA	normal	9.69^{xx}	0.0251	0.22	9.25^{xx}
		PSE	4.30^{x}	-0.0306	0.26	5.02^{x}
		DFD	2.72	-0.0234	0.18	3.01
C	BFB	normal	1.17	0.0098	0.10	1.15
		PSE	6.16^{x}	-0.0429	0.28	8.05^{xx}
		DFD	0.24	0.0072	0.04	0.23
D	BSA	normal	25.18^{xx}	-0.0576	1.00	31.79^{xxx}
		PSE	24.75^{xx}	0.0641	0.30	14.43^{xxx}
		DFD	4.93^{x}	0.0325	0.16	3.79
E	BSB	normal	7.60^{xx}	-0.0291	0.45	8.41^{xx}
		PSE	8.15^{xx}	0.0405	0.19	5.97^{x}
		DFD	0.14	0.0059	0.03	0.13

x – $P \leqslant 0.05$; xx – $P \leqslant 0.01$; xxx – $P \leqslant 0.001$

one of three linked *loci*. The distribution of Phi-Po2-Pgd haplotypes among four classes of pigs is shown in Table 1. The associacion between AFB, ASB and ASA haplotypes and meat quality has not been analysed because of their low frequency in all groups of pigs (below 5%). The relationship between each of AFA, BFA, BFB, BSA, BSB haplotypes and meat quality is shown in Table 2. A significant positive association has been observed between normal meat and

haplotypes AFA and BFA (Table 2 A and B, respectively) as well as between PSE meat and both haplotypes BSA and BSB (Table 2 D and E, respectively). A positive association between DFD meat and BSA haplotypes also proved significant (Table 2 D), but the value of $k = 3.79$ indicated that coefficient $D = 0.0325$ has not been significantly different from zero ($P > 0.05$).

Highly significant association between occurence of faulty meat (PSE and DFD) and $Phi^{B}Po2^{S}Pgd^{A}$ (BSA) and $Phi^{B}Po2^{S}Pgd^{B}$ (BSB) haplotypes linked to halothane gene Hal^{n} confirmed the correctness of limit value of criteria pH_1 and R_1 used for meat quality evaluation in this study.

Earlier studies of Andresen (1987) also showed the significant association between occurence of faulty meat and both alleles Phi^{B} and H^{a} linked to Hal locus. Haplotypes BSA and BSB used in this study for verification of criteria pH_1 and R_1 were shown to occur with significantly higher frequency within group of

TABLE 3

Determination distribution, % (explenatory variables R_1, pH_1, pH_{24}, R_{24})

Characteristics		Canonical variable							
		I group n = 148				II group n = 261			
		u_1	u_2	u_3	u_4	u_1	u_2	u_3	u_4
R_1	x_1	88.1	3.0	5.9	3.0	90.6	1.4	8.0	0.0
pH_1	x_2	98.5	1.3	0.2	0.0	96.1	3.9	0.0	0.0
pH_{24}	x_3	6.9	76.7	16.2	0.2	87.8	2.3	9.6	0.3
R_{24}	x_4	32.4	16.2	51.3	0.0	30.2	10.6	58.7	0.5
		v_1	v_2	v_3	v_4	v_1	v_2	v_3	v_4
Colour Lightnees, %	y_1	29.6	61.1	9.0	0.2	71.3	0.1	28.6	0.0
Drip loos, g	y_2	93.2	4.8	2.0	0.0	99.2	0.7	0.0	0.0
WHC	y_3	97.8	0.2	1.9	0.1	94.2	4.4	1.4	0.0
Back fat Thickness, mm	y_4	40.2	8.3	49.6	2.0	38.1	52.5	1.4	8.0
LDH activity U/l	y_5	97.5	1.0	1.5	0.0	75.9	0.0	24.0	0.1
CKP activity U/l	y_6	62.1	2.4	28.5	7.0	80.1	14.4	5.6	0.0
Coefficient of canonical correlation	C_R	0.660^{xx}	0.427^{xx}	0.311^{x}	0.124	0.622^{xx}	0.316^{xx}	0.254^{x}	0.043
Complex coefficient of correlation	R_C^2	0.195				0.147			

x – $P \leqslant 0.06$; xx – $P \leqslant 0.01$

halothane-sensitive pigs as compare to halothane-resistant animals (Gahne and Juneja, 1985; Nielsen et al., 1985; Kurył et al., 1992). Canonical analysis of significance of pH_1, R_1, pH_{24} and R_{24} criteria for meat quality evaluation showed that pH_1 and R_1 were most useful as compared to both traits pH_{24} and R_{24} (Table 3). The comparison of complex coefficients of correlation (R_c^2) showed that traits pH_1 and R_1 were a slightly more useful for meat quality diagnosis as compared to both criteria pH_1 and pH_{24} (Table 4 and 5).

The verification of correctness of the used method for meat quality evaluation was also performed on the basis of quality of meat product (hams) (Table 6). Low (1.56 points) and simultaneously 2.24 fold lower value of parameters of ham quality, evaluated for product prepared using faulty muscles, as compare to quality of ham formed using normal meat (3.88 points), confirmed the correctness of criteria pH_1 and R_1. They can be considered as criteria for porcine quality classification. The presented results (Table 6) showed that the values of pH_1 and R_1 determined in *m. longissimus dorsi* at 45 min *post mortem* allow to prognose the quality of ham produced using *m. semimembranosus, m. biceps femoris* and *m. quadriceps femoris*.

TABLE 4

Determination distribution, % (explenatory variables R_1 and pH_1)

Characteristics		Canonical variable			
		I group n = 148		II group n = 261	
		u_1	u_2	u_1	u_2
R_1	x_1	95.8	4.2	94.5	5.5
pH_1	x_2	100.0	0.0	97.7	2.3
		v_1	v_2	v_1	v_2
Colour Lightness, %	y_1	72.6	27.4	90.7	9.3
Drip loss, g	y_2	99.9	0.1	99.7	0.3
WHC	y_3	99.8	0.2	92.2	7.8
LDH activity U/l	y_5	99.9	0.1	95.3	4.7
CPK activity U/l	y_6	96.6	3.4	96.2	3.8
Coefficient of canonical correlation	C_R	0.647^{xx}	0.110	0.576^{xx}	0.280^{xx}
Complex coefficient of correlation	R_C^2	0.157		0.150	

xx – $P \leqslant 0.01$

TABLE 5

Determination distribution, % (explanatory variables R_1 and pH_1)

Characteristics		Canonical variable			
		I group n = 148		II group n = 261	
		u_1	u_2	u_1	u_2
R_1	x_1	100.0	0.0	99.8	0.2
pH_1	x_2	1.7	98.3	96.0	4.0
		v_1	v_2	v_1	v_2
Colour Lightness, %	y_1	16.7	83.3	93.4	6.6
Drip loss, g	y_2	93.9	6.1	100.0	0.0
WHC	y_3	96.8	3.2	99.9	0.1
LDH activity U/l	y_5	98.7	1.3	94.1	5.9
CPK activity U/l	y_6	93.8	6.2	98.5	1.5
Coefficient of canonical correlation	C_R	0.641xx	0.394xx	0.545xx	0.123
Complex coefficient of correlation	R_C^2	0.158		0.107	

xx – $P \leqslant 0.01$

TABLE 6

Ham evaluation in the quality classes

Quality class	Group I n = 100 II n = 104	Parameters		
		consistence (points) mean sd	slice compactness (points) mean sd	gelatine (%)
PSE	I	1.8 ± 0.29	1.5 ± 0.50	1.6
	II	1.6 ± 0.55	1.2 ± 0.45	0.7
Partly PSE	I	1.5 ± 0.50	1.3 ± 0.57	1.2
	II	1.7 ± 0.67	2.6 ± 0.89	0.3
Normal	I	3.5 ± 0.00	3.3 ± 0.29	1.4
	II	4.5 ± 0.50	4.2 ± 0.91	0.5
DFD	i	0.8 ± 0.29	1.0 ± 0.00	1.6
	II	–	–	–

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STRESZCZENIE

Praktyczna ocena metod klasyfikacji mięsa tuczników (porkerów) na podstawie pH_1 i R_1

Materiał badawczy stanowiło 1176 tuczników (porkerów) rasy polskiej białej zwisłouchej. Jakość mięsa oceniano na podstawie wskaźników fizykochemicznych oznaczanych w tkance *m. longissmus dorsi* w 45 min i 24 godz. po uboju. Poliformizm białek krwi Phi, Po2 i Pgd, determinowanych przez geny związane z reagującym na halotan locus Hal, oznaczano elektroforetycznie. Częstotliwość występowania halotypów Phi^B-$Po2^S$-Pgd^A(BSA) oraz Phi^B-$Po2^S$-Pgd^B(BSB) w grupach tuczników, których mięso zakwalifikowano jako PSE, częściowo PSE, normalne i DFD potwierdza, że najodpowiedniejszą metodą oceny jakości mięsa świń rasy polskiej białej zwisłouchej jest metoda oparta na następujących granicznych wartościach pH_1 i R_1: PSE ($pH_1 < 6.0$); $R_1 \geqslant 1.09$), częściowo PSE ($pH_1 \geqslant 6.0$); $R_1 < 1.09$), normalnie ($pH_1 \geqslant 6.0$); $R_1 < 1.09$) oraz DFD ($pH_1 \geqslant 6.0$); $R_1 \geqslant 1.09$).

Wartości pH_1 i R_1, przyjęte do oceny jakości mięsa, potwierdzono na podstawie wyników oceny szynki przygotowanej z *m. semimembranosus* (grupa I – 100 świń) oraz z *m. semimembranosus, m. quadriceps femoris* i *m. biceps femoris* (grupa II – 104 świnie). Otrzymane wyniki wskazują, że wartości pH_1 i R_1, oznaczone w *m. longissimus dorsi* w 45 min po uboju, pozwalają na przewidywanie jakości szynki konserwowej.