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EFFECT OF RYR1 GENOTYPE ON CARCASS LEANNESS AND PORK QUALITY

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ABSTRACT

The studies were carried out on 98 carcasses obtained from pure-bred Polish Landrace (PL) hogs, from crosses of (PL x Polish Large White) sows with Pietrain boars, as well as from crossbreds of Dutch breeds (Landrace x Large White) x Large White. The pigs were slaughtered as soon as they reached 103 kg of body weight, and during the slaughter blood samples were collected for DNA analysis in order to identify individuals carrying the stress-sensitivity gene (RYR1). The carcasses were dissected immediately after cooling. Samples of LD muscle from the right carcass, at the area of the 1st to 4th lumbar vertebra, were collected for pork quality evaluation, i.e. sensory analysis of raw meat, as well as pH_1, pH_k, and electric conductivity measurements. Moreover, drip loss, water-binding and meat plasticity were determined, and drip index as well as colour parameters were obtained. Basic chemical composition was also assayed and the content of water-soluble protein was determined. The pork was also estimated in terms of PSE and DFD meat incidence. The pigs genetically susceptible to stress (nn) had the highest level of carcass leanness and worse meat quality in relation to the heterozygotes (Nn) and dominant homozygotes (NN). In most of the analysed meat quality characters, the pigs of the heterozygous genotype (Nn) displayed similarity to dominant homozygotes (NN). The pigs genetically resistant to stress (NN), which had the poorest carcass leanness, were found to have the lowest content of total protein and dry matter in the meat.

Key words: pigs, RYR1 genotype, meat quality.

INTRODUCTION

The long-term selection of pigs for carcass leanness has led to some animals showing abnormalities in the form of metabolic changes undergoing in muscles after slaughter. It is expressed by the inclination of pork to deteriorate its quality and thus by an increased incidence of meat post-slaughter defects [6].

The relationship between an increased carcass leanness and pork quality deterioration has been explained mainly with the presence of the recessive form of the RYR1 gene. Recessive homozygotes (nn) are marked with a higher carcass lean meat content, which at the same time is of a poorer quality. On the other hand, dominant homozygotes (NN) have better pork quality with lower content of lean in the carcass [6, 10, 17]. The heterozygotes (Nn), which are characterised by high carcass leanness together with an optimal meat quality [1], have been described to have a particularly good set of characters.

The aim of this study was to evaluate the effect that RYR1 genotypes polymorphism has on carcass leanness as well as on the quality and basic chemical composition of pork.

MATERIALS AND METHODS

The analyses were carried out on 98 carcasses obtained from pure-bred Polish Landrace (PL) pigs, crosses of PL x Polish Large White sows with Pietrain boars, as well as from crossbreds of Dutch breeds (Landrace x Large White) x Large White. The experimental material comprised hogs managed in the same environmental conditions in the AGRO-WRONIE farm, Wronie, Poland. The feeding of the animals was uniform, with the ration balanced against energy and proteins, according to the Swine Feeding Standards [13].

At the body weight of approx. 103 kg, the hogs were slaughtered at the Meat Processing Plant in Grudziądz, Poland, during which blood samples were collected for PCR/RFLP analysis of DNA, in order to identify the animals affected with the stress-sensitivity gene (RYR1) [2, 12]. In about 45 minutes after slaughter, the meat was measured for pH (pH_1) and electric conductivity (LF_1), which was done in the LD muscle in the section located between the 4th and 5th lumber vertebra of the right-side carcass. After 24-hour cooling, the carcasses were dissected according to the methods by Walstra and Merkus [18]. The dissection also allowed collecting samples of the *longissimus dorsi* (LD) muscle at the 1st-4th lumbar vertebrae of the right-side carcass.

In about 48 hours after slaughter, sensory analyses of raw meat were carried out according to Clausen and Thomsen, which included colour, wateriness, and firmness [15]. Moreover, drip loss was measured according to Honikel [4]. In minced meat samples, pH_k was measured in water extract and water-holding capacity was determined with the method by Grau and Hamm, modified by Pohja and Niinivaara [14]; also the so called *drip index* (IN) was calculated as the ratio of surface area of a squashed sample, referred to as plasticity, to the area of the leakage. Meat colour was determined spectrophotometrically with the simplified method [16], which allowed calculating particular parameters of colour, i.e. the dominant wave-length, saturation, and lightness. The meat was assayed for its basic chemical composition, i.e. protein, fat, ash, and dry matter, according to methods by Kortz [7]; water-soluble proteins content was determined according to Kotik [8]. Also the frequency of PSE and DFD meat was estimated based on the Q_8, according to Grajewska et al. [3]. Statistical analysis and verification of differences in the meat quality traits occurring between the individual genetic groups were done with one-way ANOVA using STATISTICA PL, v. 6.0 software.

RESULTS AND DISCUSSION

The studies allowed confirming the significant effect of the nn genotype on lean content in the carcass. The animals of this genotype were characteristic for the highest carcass leanness (Table 1) in relation to the hogs of the heterozygous genotype (Nn), and those genetically resistant to stress (NN), which confirmed the results of previous studies by other authors [6, 17]. On the other hand, the results of the studies [1] were not confirmed, where the heterozygotes (Nn) had higher carcass lean content in relation to the homozygotes resistant to stress (NN), as no significant differences were found between these genotypes.

Table 1. Means ($\bar{x}$) and standard deviations (s) of physicochemical traits of meat in relation to RYR1 genotype

Trait		RYR1 genotype		
		nn n = 11	Nn n = 36	NN n = 51
Carcass lean content (%)	$\bar{x}$	56.01^{A}	52.05^{B}	51.60^{B}
	s	1.98	3.55	2.96
Hot carcass weight	$\bar{x}$	79.07	80.70	80.36
	s	4.10	4.84	4.22
pH_1	$\bar{x}$	5.71^{A}	6.02^{B}	6.36^{C}
	s	0.14	0.31	0.33
pH_k	$\bar{x}$	5.51	5.50	5.52
	s	0.11	0.15	0.10
LF_1 (mS/cm)	$\bar{x}$	8.78^{A}	4.42^{B}	3.63^{B}
	s	4.21	1.35	0.96
Lightness (%)	$\bar{x}$	30.12^{A}	26.94^{B}	25.11^{B}
	s	5.26	4.83	3.05
Saturation (%)	$\bar{x}$	24.27^{A}	21.64^{B}	20.11^{C}
	s	2.95	2.69	2.01
Drip loss (%)	$\bar{x}$	6.69^{A}	4.50^{B}	2.50^{C}
	s	2.18	2.45	1.33
Bound water content (% of total water)	$\bar{x}$	67.44^{A}	70.73^{B}	73.10^{B}
	s	3.77	4.68	3.74
Plasticity (cm^2)	$\bar{x}$	1.78^{A}	2.00^{B}	2.24^{C}
	s	0.22	0.25	0.28
Drip index (cm^2)	$\bar{x}$	0.20^{A}	0.24^{B}	0.27^{C}
	s	0.04	0.05	0.05
Water-soluble protein (% in meat)	$\bar{x}$	7.02^{A}	8.54^{B}	8.54^{B}
	s	0.76	1.22	0.82

A, B, C - differ significantly at $p \leq 0.01$.

The results of the sensory analysis (Table 2) allow a definite conclusion that the genetically-susceptible to stress hogs (nn) produced meat of the worst quality, as they showed the lowest parameter values of colour, wateriness, and firmness, and differed significantly from those of the heterozygous genotype (Nn) and the dominant homozygotes (NN). It was also found that the genetically resistant to stress hogs (NN) were characterised by the highest mean scores of the sensory analysis, while the heterozygote group (Nn) of hogs showed intermediate values in relation to the nn and NN genotype groups of pigs. Statistically significant differences were also found in the plasticity of meat between the hogs of the NN, Nn, and nn genotypes.

Table 2. Means ($\bar{x}$) and standard deviations (s) of sensory traits of meat in relation to RYR1 genotype

Trait		RYR1 genotype		
		Nn n = 11	Nn n = 36	NN n = 51
Colour (points)	$\bar{x}$	2.00^{A}	2.46^{B}	2.60^{B}
	s	0.62	0.60	0.42
Wateriness (points)	$\bar{x}$	1.79^{A}	2.34^{B}	2.68^{B}
	s	0.56	0.62	0.42
Firmness (points)	$\bar{x}$	1.99^{A}	2.60^{B}	2.80^{B}
	s	0.65	0.54	0.39

A, B – differ significantly at $p \leq 0.01$.

The meat of the hogs of the nn genotype, of the highest carcass lean meat content, was characterised by the lowest mean pH_1, the highest electric conductivity, the highest colour lightness and saturation, drip loss, the lowest bound water content, the lowest drip index, and the lowest water-soluble protein content in relation to the meat of the hogs of the heterozygous genotype (Nn) and those genetically resistant to stress (NN), (Table 1). The presented results confirm the negative relationship between carcass lean meat content and the quality characters of meat. This negative effect grows with an increased percentage of the nn-genotype pigs [1].

The heterozygous Nn-genotype hogs, in respect to such traits as electric conductivity, colour lightness, bound water and water-soluble protein content, are closer to the dominant homozygotes (NN). According to pH_1, however, colour saturation, drip loss, and drip index, the heterozygotes were characterised by intermediate values in relation to the nn- and NN hogs (Table 1).

Total protein content (Table 3) was the lowest in the group of pigs resistant to stress (NN), which had the lowest carcass leanness in relation to the Nn and nn pigs, which in turn indicates that total protein content in muscles grows with increased leanness. Total protein content probably influenced the differences in dry matter content between the discussed genotypes, as the stress-resistant NN-genotype hogs showed its lowest level.

Table 3. Means ($\bar{x}$) and standard deviations (s) of chemical composition of meat in relation to RYR1 genotype

Meat quality grade		RYR1 genotype			Total
		Nn n = 11	Nn n = 36	NN n = 51	
PSE	n	3	1	-	4
	%	27	3	-	5
Partly PSE	n	1	6	1	8
	%	9	17	2	8
Normal	n	7	25	46	78
	%	64	69	90	79
Partly DFD	n	-	4	4	8
	%	-	11	8	8

Table 4. Frequency of normal and defective meat in relation to RYR1 genotype

Trait		RYR1 genotype		
		Nn n = 11	Nn n = 36	NN n = 51
Protein (%)	$\bar{x}$	23.04^A	22.63^A	22.00^B
	s	0.77	0.79	0.75
Fat (%)	$\bar{x}$	1.72	2.15	2.19
	s	0.46	0.79	0.82
Ash (%)	$\bar{x}$	1.12	1.09	1.10
	s	0.07	0.14	0.21
Dry matter (%)	$\bar{x}$	25.92^A	25.99^A	25.37^B
	s	0.61	0.90	0.72

A, B - differ significantly at $p \leq 0.01$.

Analysing the frequency of normal versus defective meat (Table 4), it was found that not all the stress-sensitive hogs (nn) displayed PSE meat (64%). What is more, partly-PSE meat (2%) was found as well as DFD meat (8%) in those genetically-resistant to stress (NN). Among the heterozygous genotype animals (Nn), the largest number of carcasses were with normal meat (69%), then with partly-PSE meat (17%) and DFD meat (11%), and the least number of carcasses had PSE meat (3%). On the other hand, the largest proportion of normal meat in the entire material was found in the NN hogs. The results confirm previous results by other authors [5, 9, 11], who reported the most cases of PSE meat in the group of stress-sensitive homozygotes (nn), in comparison with heterozygotes (Nn) and dominant homozygotes (NN).

CONCLUSIONS

1. The pigs genetically sensitive to stress (nn) displayed the highest carcass lean meat content and poorer meat quality in relation to the heterozygous hogs (Nn) and dominant homozygotes (NN).
2. The hogs of the heterozygous genotype (Nn) display similarity to dominant homozygotes (NN) in most of the analysed meat quality characters.
3. The pigs genetically resistant to stress (NN), which had the poorest carcass leanness, were found to have the lowest content of total protein and dry matter in the meat.

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