Carcass and meat quality traits of pig reciprocal crosses with a share of Pietrain breed

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ABSTRACT: The study was carried out on 119 hybrid grower-finisher pigs that were divided into 5 experimental groups. The analysis covered carcass and meat quality traits of crossbred pigs produced by mating Polish Large White × Polish Landrace crossbred sows with boars of either purebred Pietrain (P) or crossbreds of Line 990 × Pietrain (LP), or Pietrain × Line 990 (PL), or Duroc × Pietrain (DP), or Pietrain × Duroc (PD). The analysis of results which include the effect of the *RYR1* gene polymorphism showed that porkers descending from Pietrain boars (P) had a higher meat content in the carcass and a larger loin eye area in comparison with porkers descending from DP and PD boars, and a larger loin eye area in comparison with porkers descending from boars that were LP crosses. Meat of porkers descending from Pietrain boars had lower water-holding capacity (WHC) and higher lightness (L^*) in comparison with porkers descending from crossbred boars where the Pietrain breed was used on the paternal side (LP and DP). Meat of porkers descending from Pietrain boars had a lower content of water-soluble protein compared to other groups with a 25% share of the Pietrain breed. In addition, no significant influence of the position effect on carcass and meat quality was found out in porkers obtained from the crossing of sows of the White breed with crossbred boars descending from two-way crosses of the Pietrain breed with Line 990 (LP and PL) and with the Duroc breed (DP and PD).

Keywords: pigs; reciprocal crosses; carcass and meat quality; *RYR1* genotype

An increase in meat content in the general population of porkers is a result of continuous improvement of maternal domestic white breeds and of the use of paternal breeds with a high meat content, especially of the Pietrain breed. However, the use of Pietrain porkers in many European breeding programmes has revealed a number of problems associated with the sensitivity of this breed to stress, and consequent adverse effects on meat quality (Larzul et al., 1997; Biedermann et al., 2000). One approach to reducing the defects that occur with a high frequency in this breed is crossbreeding. The main effort is focused on the development of the best possible crossing variants in order to maximise the benefits of increased meat content and quality. Modern crossing programmes involve the production of crossbreds derived from maternal pig breeds with a high meat content but without the allele *RYR1 T* and paternal breeds not always free of this allele (Rosner et al., 2003). Although crossing programmes involve crossbred boars and crossbred sows, the question remains whether an individual of a specific breed used to produce the crossbred boars should be used on the maternal or paternal side. So far, no studies have examined the meat and carcass quality of porkers from a two-way crossing of the Pietrain breed with the Duroc breed and Line 990, subsequently used to cross with

crossbred sows originating from the Polish Large White and Polish Landrace breeds.

The aim of this paper was to determine the effect of crossbred boars, reciprocal crosses of the Pietrain breed with the Duroc breed and Line 990, on the carcass and meat quality of their offspring, also taking into account the *RYR1* gene polymorphisms.

MATERIAL AND METHODS

The study was carried out on 119 crossbred grower-finisher pigs from Polish Large White × Polish Landrace sows sired by Pietrain boars (P) and their crossbreds with Line 990 (LP, PL) and Duroc (DP, PD), distributed into 5 experimental groups (Table 1). Each group comprised 24 pigs (12 barrows and 12 gilts), obtained from 3 sires and 12 sows by crossing each boar with four different sows. The animals (one gilt and one boar from a single litter) were selected for the analyses at about 100 days of age and average body weight of about 34 kg. The animals were individually kept and fed on a pig farm at the Experimental Station of Animal Production (National Research Institute of Animal Production) in Kołbacz, Poland. The energy value and basic chemical composition of feed mixture used in the study were consistent with 1993 Pig Nutrition Standards.

After reaching 100 ± 2 kg body weight, pigs were slaughtered and blood samples were collected for DNA analysis to identify all genotypes at *RYR1* loci. During the slaughter operation, meat acidity (pH_1) was measured 45 min after bleeding (pH-meter CP-411, Elmetron) in the *longissimus dorsi* (LD) muscle between the 4th and the 5th lumbar vertebra of the right half-carcass. The warm carcass weight was also determined. The mean carcass weight was 81.02 ± 1.33 kg. After 24-h chilling, the carcasses were dissected according to the methods used at Swine Testing Stations (Różycki, 1996) and the meat pH_{24} was determined. The dissection results were then used for the calculation of carcass lean content. During cutting, meat samples were collected from the LD muscle from the lumbar vertebrae 1 to 4 section of the right half-carcass. Approximately 48 h after slaughter, pH measurement was done in a water solution on mixed and diluted muscle tissue, meat colour lightness (L^*) was determined by means of HunterLab Mini Scan XE 45/0 apparatus (CIE, 1976), water-holding capacity was determined by the Grau and Hamm (1952) method as modified by Pohja and Niinivaara (1957), thermal drip from a difference in meat sample weight before and after heating in water bath at 85°C for 10 min, water-soluble protein content by the Kotik (1974) method, as well as the assay of meat basic chemical composition, i.e. total protein, fat, ash, and dry matter (AOAC, 2003), was carried out. The examination of longissimus dorsi muscle tenderness (the last four thoracic vertebrae) was performed by means of an Instron 1140 Universal Testing Machine (Instron, High Wycombe, UK) using the Warner-Bratzler test. The DNA analysis, by PCR/RFLP technique, was performed in the Institute of Genetics of the Mendel University in Brno, Czech Republic. The *RYR1* genotypes were identified by means of *Hin*PI endonuclease (Fujii et al., 1991).

The statistical analysis was performed to compare carcass and meat quality traits and meat basic chemical composition in pigs of different experimental groups, using the least squares method of the GLM procedure (Statistica 8.0 PL) according to the following linear model:

$$Y_{ijk} = \mu + a_i + b_j + e_{ijk}$$

where:

Y_{ijk} = trait measured

μ = overall mean

a_i = effect of experimental groups (i = P, LP, PL, DP, PD)

b_j = effect of *RYR1* genotype (j = *TT, CT, CC*)

e_{ijk} = random error

Detailed comparison of the LSQ means for the analysed experimental groups was done using Tukey's test.

RESULTS AND DISCUSSION

The frequency of alleles and genotypes against the *RYR1* gene in each experimental group is shown in Table 2. Means and standard deviations for the quality traits of carcasses and meat from the five experimental groups of porkers are presented in Table 3.

The results show that porkers descending from Pietrain boars (P) were characterised by a significantly higher content of meat in the carcass compared to porkers descending from crossbred boars of Pietrain and Duroc breeds (DP and PD). In addition, the carcasses of porkers coming from Pietrain sires had a significantly larger loin eye area than

Table 1. Experimental groups

Group	Paternal component	Maternal component
P	Pietrain boars	crosses sows (Polish Large White × Polish Landrace)
LP	crosses boars (♀ Line 990 × ♂ Pietrain)	
PL	crosses boars (♀ Pietrain × ♂ Line 990)	
DP	crosses boars (♀ Duroc × ♂ Pietrain)	
PD	crosses boars (♀ Pietrain × ♂ Duroc)	

those of the porkers from LP, DP, and PD groups. No significant differences were found out among all the analysed groups in backfat thickness determined on the basis of 5 measurements of the back.

With respect to the basic chemical composition of analysed meat, porkers descending from crossbred boars significantly differed only in dry matter content of meat. The lowest dry matter content of meat was found out in the PL group. Significant differences occurred between PL and DP, and between PL and PD groups. In addition, meat from LP porkers contained less dry matter than that of the PD group. Studies by other authors showed the more desirable carcass values of crossbreds descending from Pietrain boars than in porkers with a 25% share of this breed (Jasek et al., 1998; Krzęcio et al., 2004). In addition, other reports have shown the worse carcass quality of porkers descending from boars that were crossbreds of Pietrain and Duroc porkers compared to those descending from the crosses of Pietrain and Hampshire (Šimek et al., 2004).

Meat of porkers descending from Pietrain boars (P) was significantly lighter in colour (L^*) and had a lower water-holding capacity (WHC) in comparison with those descending from crossbreds in which the Pietrain breed was used on the paternal side (LP and DP). Also, the meat of porkers descending from Pietrain boars had the significantly lowest content of water-soluble protein compared to meat from porkers descending from crossbred boars, LP, PL, DP and PD, in which the proportion of the Pietrain breed genotype was only 25%. In addition, meat of DP crossbred porkers had a significantly lower thermal drip compared to the meat of LP porkers in LP group. There were no significant differences among the analysed groups of porkers in meat acidity (pH) measured 45 min, 24 and 48 h after slaughter and in meat tenderness.

The obtained results indicate slightly lower quality of meat in porkers descending from Pietrain boars (P) compared to porkers descending from crossbred boars, with respect to water-holding capacity (WHC), lightness (L^*) and content of water-soluble protein. Similar results were obtained by other authors (Edwards et al., 2003; Kuhn et al., 2005) who reported a tendency of deterioration in meat quality in crossbreds descending from Pietrain boars in comparison with crossbreds descending

Table 2. Genotype and allele frequencies of *RYR1* in experimental groups

Group		*RYR1* genotypes			Allele frequencies
		CC	*CT*	*TT*	
P	*n*	0	20	4	*C* = 0.417
	%	0	83.3	16.7	*T* = 0.583
LP	*n*	8	14	2	*C* = 0.625
	%	33.3	58.3	8.3	*T* = 0.375
PL	*n*	4	19	0	*C* = 0.587
	%	17.4	82.6	0	*T* = 0.413
DP	*n*	8	15	1	*C* = 0.644
	%	33.3	62.5	4.2	*T* = 0.354
PD	*n*	11	12	1	*C* = 0.708
	%	45.8	50.0	4.2	*T* = 0.292

Table 3. The LSQ means and their standard deviations (SD) for carcass and meat quality traits

Traits	Experimental groups				
	P	LP	PL	DP	PD
Lean content of carcass (%)	$55.20^{a} \pm 3.21$	53.46 ± 2.94	53.87 ± 3.15	$52.7^{b} \pm 2.52$	$52.8^{b} \pm 3.27$
Mean backfat thickness from 5 measurements (cm)	2.29 ± 0.34	2.38 ± 0.36	2.40 ± 0.29	2.47 ± 0.47	2.38 ± 0.37
Loin eye area (cm^2)	$49.83^{A} \pm 5.53$	$44.18^{B} \pm 5.04$	46.56 ± 3.88	$44.86^{B} \pm 4.56$	$43.90^{B} \pm 6.40$
Crude protein (%)	23.49 ± 0.58	23.28 ± 0.75	23.38 ± 0.43	23.75 ± 0.79	23.60 ± 0.68
Intramuscular fat (%)	2.43 ± 0.73	2.66 ± 0.90	2.28 ± 0.77	2.66 ± 0.86	2.74 ± 0.77
Ash (%)	1.15 ± 0.12	1.18 ± 0.15	1.21 ± 0.11	1.14 ± 0.09	1.12 ± 0.11
Dry matter (%)	26.42 ± 0.63	$26.19^{a} \pm 0.55$	$25.90^{A} \pm 0.69$	$26.67^{B} \pm 0.69$	$26.77^{Bb} \pm 0.88$
pH_1	6.15 ± 0.33	6.20 ± 0.35	6.14 ± 0.33	6.29 ± 0.33	6.35 ± 0.29
pH_{24}	5.45 ± 0.09	5.42 ± 0.07	5.42 ± 0.08	5.43 ± 0.09	5.43 ± 0.12
pH_{48}	5.36 ± 0.09	5.40 ± 0.06	5.36 ± 0.07	5.40 ± 0.07	5.39 ± 0.09
Meat lightness (L^*)	$55.51^{a} \pm 1.95$	$53.78^{b} \pm 1.99$	54.39 ± 2.22	$53.52^{b} \pm 2.21$	54.16 ± 1.87
Tenderness (N/kg)	72.04 ± 16.34	71.90 ± 18.67	77.23 ± 24.62	73.07 ± 19.39	67.40 ± 16.56
Thermal drip (%)	30.13 ± 2.52	$30.67^{a} \pm 3.25$	30.04 ± 2.70	$28.26^{b} \pm 2.39$	29.75 ± 2.41
WHC (cm^2)	$6.68^{Aa} \pm 1.15$	$5.70^{b} \pm 1.20$	6.30 ± 1.07	$5.55^{B} \pm 1.32$	$5.67^{b} \pm 1.14$
Water-soluble protein (%)	$8.41^{Aa} \pm 0.86$	$9.21^{b} \pm 1.04$	$9.22^{b} \pm 1.17$	$9.59^{B} \pm 1.04$	$9.46^{B} \pm 0.94$

^{a,b}mean values in rows marked by different letters differ significantly at $P \leq 0.05$

^{A,B}mean values in rows marked by different letters differ significantly at $P \leq 0.01$

from the Duroc breed. As reported by Šimek et al. (2004), when Pietrain × Duroc boars are crossed with sows of the White breed, it improves the meat content of the offspring without a decline in the technological value of meat.

Literature indicates that higher meat content in carcass and worse meat quality in crossbreds descending from Pietrain boars may be due to a high frequency of the *T* allele at the *RYR1* gene. Differences in the quality of carcass and particularly in meat quality between breeds or crossbreds are connected primarily with the presence of a varying frequency of *RYR1* genotypes, as documented by the results of other reports (Larzul et al., 1997; Fiedler et al., 1999). For example, Biedermann et al. (2000) showed that in porkers descending from Pietrain boars, a decreasing share of the *T* allele is followed by reduced carcass value, improved meat quality, and increased content of intramuscular fat. It is commonly observed that a negative correlation between the muscle content of carcass and meat quality occurs in porkers with a higher frequency of the *T* allele, and is less marked in porkers with the *RYR1 CC* genotype. This is confirmed by the studies on porkers free of the *RYR1 T* allele which indicate that the use of Pietrain boars with the *RYR1 CC* genotype does not contribute to the deterioration of the quality of either carcass or meat in the resultant crossbred porkers (Fàbrega et al., 2004). However, Škrlep et al. (2010) did not prove any major effect of *RYR1* genotypes on carcass traits, but a negative effect on meat quality traits was observed in porkers after Pietrain boars and in their crossbreds.

This study also analysed the influence of a position effect in two-way crossing on carcass and meat quality traits in porkers. The analysis of results showed no significant differences in carcass and meat quality traits between groups of porkers descending from Pietrain and Line 990 boars (LP and PL) and between groups of porkers descending from boars that were crosses of Pietrain and Duroc breeds (DP and PD). This result is confirmed by other studies which analysed the effect of two-way crossing on the formation of carcass traits and meat quality in offspring (Ellis et al., 1995; Michalska

and Nowachowicz, 1998; Michalska et al., 2000). By contrast, Lo et al. (1992) demonstrated the effect of two-way crossing of Landrace and Duroc porkers on the intramuscular fat content in meat. According to these authors, the use of Duroc breed on the paternal side increased the content intramuscular fat. Michalska et al. (2007) also noted the effect of two-way crossing on meat and fat content in porker carcasses. These authors found out that the use of the Polish Landrace breed on the maternal side and of the Large White Polish on the paternal side increased meat content and decreased backfat thickness in porkers in comparison with the reverse combination of these breeds.

CONCLUSIONS

The analysis of results which include the effect of the *RYR1* gene polymorphism showed that porkers descending from Pietrain boars (P) had a higher meat content in the carcass and a larger loin eye area in comparison with porkers descending from DP and PD boars, and a larger loin eye area in comparison with porkers descending from boars that were LP crosses. The meat of porkers descending from Pietrain boars had lower water-holding capacity (WHC) and higher lightness (L^*) in comparison with porkers descending from hybrid boars where the Pietrain breed was used on the paternal side (LP and DP). Meat of porkers descending from Pietrain boars had a lower content of water-soluble protein compared to other groups with a 25% share of the Pietrain breed. In addition, no significant influence of the position effect on carcass and meat quality was found out in porkers obtained from the crossing of sows of the White breed with crossbred boars descending from two-way crosses of the Pietrain breed with Line 990 (LP and PL) and with the Duroc breed (DP and PD).

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