

## **Quality and technological suitability of pork meat from Zlotnicka Spotted pigs and their crossbreeds with Duroc and Polish Large White**

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The subject of the study was dry-cured rump and smoked belly made from meat obtained from Zlotnicka Spotted (ZS) pigs and their crossbreeds with the Duroc (D) and Polish Large White (PLW). Weight gain after curing, smoking losses, pH, lightness (L\*a\*b\*) and NaCl content were determined and a sensory evaluation the meat products was performed. Cross-breeding of ZS pigs with the D and PLW breeds resulted in an increase in carcass meatiness of about 1 pp and 4 pp, respectively, and a decrease in backfat thickness of about 3 to 9 mm. In all genetic groups meat of very good quality with no quality defects was obtained. In the rump muscles of the ZS pigs a lower level of intramuscular fat was observed (2.25%) than in the crossbred pigs (about 2.9%). The quality of the meat products prepared from the meat of the groups of pigs studied did not differ significantly in terms of most technological parameters and physico-chemical and sensory characteristics. The dry-cured rump and smoked belly received high ratings for sensory traits, on average above 4.5 pts on a 5-point scale. Cross-breeding had no adverse effect on the quality of the meat products and increased the slaughter value of the fatteners, especially in the case of the ZS x PLW cross-breeds.

**KEY WORDS:** Zlotnicka Spotted / dry cured rump / smoked belly / quality

Polish meat processors are showing increasing interest in offering consumers more shelf-stable products, which are thus more expensive and included among luxury goods. These include dry-cured products, which are very popular in southern Europe and increasingly available in Poland. In many countries the material for their production is obtained from animals of native breeds. Native breeds of pigs in Poland include Zlotnicka Spotted,

Zlotnicka White and Pulawska. In many European countries old breeds of pig are under special protection. An example is Italy, which has five native breeds, including the ancient breed Casertana and the primitive Sarda pig [18, 21]. The carcasses of these pigs have thick backfat and their meat is valued for its distinctive flavour. The meat of these breeds is especially suitable for production of Parma ham. In Spain, the meat of the native Iberian pig breed is used for production of dry-cured products, particularly jamón Serrano [24]. In France, it is worth noting the native Basque pig, which provides material for the production of Bayonne ham [22]. Pugliese and Sirtori [17] conducted an analysis of native pig breeds from southern Europe, focusing in particular on the effect of genetics and farming systems on the quality of the product. They found that inferior performance and lower lean meat content were observed in native breeds than in breeds with high meat content [9], but their meat is of excellent quality.

In Poland pigs of the Zlotnicka breeds are a population of unique genetic value. Due to their tendency towards high fat cover their carcass value is inferior to that of white breeds [5, 7, 23]. They are less suitable for commercial production because of their lower lean meat content [3, 7].

The production results of native breeds can be improved through cross-breeding [23]. To prevent the loss of the quality attributes of the meat, an appropriate choice of components for cross-breeding with the Zlotnicka breed is essential. Due to the favourable quality parameters of their meat, the Duroc and Polish Large White (LPW) breeds seem particularly suited to crossing with this breed. The Duroc breed, considered to be resistant to stress, provides meat of similar quality to that of LPW pigs [10].

The aim of the study was to determine the effect of crossing Zlotnicka Spotted pigs with boars of the Duroc and Large Polish White breeds on the qualitative parameters of selected products, i.e. dry-cured rump and smoked belly.

### Material and methods

The material for the study consisted of 50 fattening pigs from four genetic groups, according to the experimental design presented in Table 1.

**Table 1**  
Experimental design

Group	Breed group	Group symbol	Number (head)
1	Zlotnicka Spotted	ZS	20
2	Zlotnicka Spotted x (Zlotnicka Spotted x Duroc)	ZS x ZS x D	10
3	Zlotnicka Spotted x Duroc	ZS x D	10
4	Zlotnicka Spotted x Polish Large White	ZS x PLW	10

In all groups the ratio of gilts to young boars was 1:1. The pigs in each group were kept in group pens and feeding was *ad libitum*. The diet and housing conditions were the same for all groups and in compliance with animal production standards adopted in 1993.

When the animals had reached a weight of  $120 \pm 7$  kg they were slaughtered by the same technology (electric stunning, bleeding in a hanging position, and cooling by the one-stage method). Meat content was measured on hot, hanging left half-carcasses using an UltraFom 300 ultrasound probe, and backfat thickness was determined above the shoulder, on the back and on the ham [2]. The pH value was determined 45 min ( $\text{pH}_{45}$ ) and 24 h ( $\text{pH}_{24}$ ) after slaughter, using a PHM 80 Radiometer with a combination electrode. Both measurements were made in the longissimus dorsi muscle (LD) and the semimembranosus muscle (SEM). Then the carcasses were dissected into primal cuts.

The material for the study consisted of rumps and bellies without ribs, trimmed according to meat industry regulations [14]. The rumps were well cooled, arranged in layers in containers, and dry-cured for 14 days with a pickling spice mix containing sodium chloride (79.4%, including 0.05% sodium nitrite), saccharose (6%), crystalline glucose (6.4%), starter cultures (1.1%), juniper (2%), allspice (1%), bay leaf (2%), and black pepper (2.1%). The pickling spice mix was added in the amount of 50 g per kg of meat. The ageing process continued for 10 days in a room with a temperature of 8-10°C and relative humidity of about 80%. Next the salt was removed from the rumps and they were dried in a smokehouse at 18 to 25°C for 12 h and smoked by a traditional system for about 6 h with smoke at a temperature of 20°C and relative humidity of about 70%.

The belly, following removal of the skin and fat deposits, was trimmed to a rectangular shape. A Mifam 501 manual injection device was used to inject the muscle with 10% brine with respect to the weight of the belly. The composition of the injected brine was as follows: water (84.42%), table salt (9%), sugar (5%), protein hydrolysate (0.70%), sodium ascorbate (0.45%), sodium nitrate (0.30%), and sodium nitrite (0.13%). Next the bellies were layered in containers and brine was poured on them, maintaining a 0.5:1 proportion of brine to belly. The composition of this brine was as follows: water (90.57%), table salt (9%), sodium nitrate (0.30%), and sodium nitrite (0.13%). Curing time was three days and drip time was four days, at a temperature of 4-6°C and relative humidity of 85-90%. Then the bellies were smoked for about 4 h with smoke at a temperature of 25-35°C, to achieve a light brown colour, and then placed in cold storage at 6°C.

Samples of fresh rump were taken for laboratory testing and the following were determined: moisture content by the oven-dry method according to PN ISO 1442:2000 [15], fat by the Soxhlet method according to PN ISO 1444:2000 [16], and total protein by the Kjeldahl method—PN-75/A-04018, using equipment from Tecator [13]. In the dry-cured rump and smoked belly pH was measured, changes in weight during processing (curing or smoking) were determined, and the yield of finished product was established.

L\*a\*b\* colour parameters were determined on a cross-section of the rump using a Konica Minolta CR-400 Chroma Meter, and marbling was evaluated on a 5-point scale (1 pt. – light marbling, 5 pts. – heavy marbling). Sodium chloride content was determined in the rump samples by the Mohr method according to PN-73A-82112 [12]. On a cross-section of the middle part of the smoked belly measurements were made of the thickness of the subcutaneous fat layer and the meat layer, and the ratio of the thicknesses of these layers was calculated.

Sensory evaluation of the products was carried out by a trained panel, using a 5-point scale to specify consistency, colour (desirability and uniformity), aroma, juiciness, tenderness and palatability [1].

Statistical analysis of the results was performed using Statistica 6.0 software, calculating means ( $\bar{x}$ ) and standard deviations (Sd). Statistical significance between means for groups was determined by one-way analysis of variance using Tukey's test [19].

## **Results and discussion**

The data presented in Table 2 indicate that cross-breeding significantly ( $p \leq 0.05$ ) affected the meatiness of the pigs, as well as the surface area of the eye of the loin. The highest meat content was noted in the crosses with the LPW breed (48%), and the lowest (about 42.5%) in the ZS x (ZS x D) crosses. The larger contribution of the Duroc breed (ZS x D) proved more efficient in improving meat content than the 25% contribution of this breed. The surface area of the loin eye was about 7 cm<sup>2</sup> larger in the crosses of all three groups than in the purebred Zlotnicka Spotted pigs.

A significant ( $p \leq 0.05$ ) effect of the genetic group on the thickness of subcutaneous fat was observed as well. Thicker backfat was observed in the purebred pigs and in the group with the small contribution of the Duroc breed. Backfat was 3 to 9 mm thicker than in the other groups of pigs.

In an experiment by Strzelecki et al. [20], in which the Zlotnicka White breed was crossed with LPW, similar effects were obtained as in the present study, i.e. an increase in lean meat content from 46.4% to 49.7%, an increase in the area of the loin eye from 36.2 to 42.2 cm<sup>2</sup>, and a decrease in mean backfat thickness from 4.1 to 3.1 cm. Considerably better effects were obtained in a study in which ZS pigs were crossed with the Pietrain breed. In these crosses (ZS x PI) Wajda and Meller [25] obtained mean lean meat content of 53.2%. These pigs were also distinguished by a larger loin eye area and thinner backfat. Increasing the contribution of the Pietrain breed to 75% led to further improvement in carcass characteristics. Nevertheless, crossing of Zlotnicka pigs with the Pietrain breed is risky due to the occurrence of PSE meat in the crosses. The authors demonstrated that the meat of F<sub>1</sub> pigs was similar in this respect to that of Zlotnicka pigs, while the meat of F<sub>2</sub> pigs was similar to that of the Pietrain breed [25]. Other authors have reported a similar low level of meat content in the carcasses of Zlotnicka pigs, ranging from 43.5% to about 46% [3, 7].

**Table 2**  
Selected carcass and meat characteristics

Trait	Breed group							
	ZS x ZS		ZS (ZS x D)		ZS x D		ZS x PLW	
	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd
Hot carcass weight (kg)	88.92	6.29	90.57	6.08	88.57	5.46	87.26	5.76
Meat content (%)	43.99 <sup>a</sup>	55.4	42.47 <sup>a</sup>	3.41	45.02 <sup>a</sup>	3.61	48.00 <sup>b</sup>	3.47
Mean backfat thickness from five measurements (cm)	4.22 <sup>b</sup>	0.93	4.51 <sup>b</sup>	0.97	3.86 <sup>a</sup>	0.52	3.61 <sup>a</sup>	0.36
Loin eye area (cm <sup>2</sup> )	29.61 <sup>a</sup>	5.46	36.63 <sup>b</sup>	7.05	35.24 <sup>b</sup>	4.77	35.97 <sup>b</sup>	5.61
pH <sub>45</sub> m. LD	6.39	0.31	6.26	0.36	6.38	0.25	6.42	0.26
pH <sub>45</sub> m. SEM	6.32	0.28	6.12	0.30	6.26	0.26	6.32	0.27
pH <sub>24</sub> m. LD	5.50	0.09	5.51	0.17	5.41	0.08	5.40	0.09
pH <sub>24</sub> m SEM	5.76	0.20	5.74	0.18	5.68	0.17	5.62	0.22
Moisture content in rump muscle (%)	71.30 <sup>a</sup>	0.85	70.31 <sup>b</sup>	0.99	70.74 <sup>a</sup>	0.72	70.64 <sup>a</sup>	0.93
Fat content in rump muscle (%)	2.25 <sup>a</sup>	0.68	2.79 <sup>b</sup>	0.62	2.89 <sup>b</sup>	0.59	2.90 <sup>b</sup>	0.37
Protein content in rump muscle (%)	25.10	1.01	25.6	1.23	25.07	0.57	25.16	1.03

ZS – Zlotnicka Spotted, D – Duroc, PLW – Polish Large White  
a, b – means with different superscripts are significant at  $p \leq 0.05$

Analysis of the pH (Tab. 2) of the muscles showed no quality defects such as PSE ( $\text{pH}_{45} \leq 5.8$ ) or DFD ( $\text{pH}_{24} > 6.3$ ). This suggests that the population studied was not burdened with the *RYRI* gene, which negatively affects meat quality, leading to increased frequency of PSE meat [8]. Comparison of fat content in the fresh rump of the groups analysed revealed that the Duroc breed significantly ( $p \leq 0.05$ ) increased the content of intramuscular fat in the crosses as compared to the purebred Zlotnicka Spotted pigs (about 2.89% and 2.25%, respectively). The Duroc breed has more intramuscular fat than other breeds, as confirmed in studies by many authors [4, 6, 10]. A similar high level of intramuscular fat was noted in the rump of the ZS x LPW crosses (2.90%).

In the production process no significant differences were noted between groups in the technological parameters tested. Initial and final pH were similar (5.47 to 5.71) and did not differ significantly between groups (Tab. 3). Weight loss after curing of the rump was similar in all groups, ranging from 4.81% to 5.23%. In contrast, significantly greater weight loss after smoking was observed in the rump from the purebred pigs and the crosses

**Table 3**  
Weight loss and pH of dry cured rumps during processing

Studied trait	Breed group							
	ZS x ZS		ZS (ZS x D)		ZS x D		ZS x PLW	
	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd
pH initial	5.50	0.15	5.55	0.18	5.47	0.11	5.44	0.09
pH after curing	5.63	0.11	5.69	0.14	5.63	0.07	5.63	0.08
pH after smoking	5.65	0.05	5.71	0.17	5.68	0.06	5.66	0.08
pH after ageing	5.60	0.10	5.62	0.09	5.70	0.11	5.65	0.10
Weight before curing (g)	1260.7	281.7	1350.4	218.2	1151.9	203.3	1301.7	256.1
Weight loss after curing (%)	4.81	1.30	4.55	1.25	5.23	1.32	5.08	1.28
Weight loss after smoking (%)	10.75 <sup>a</sup>	1.57	9.47 <sup>b</sup>	1.49	10.69 <sup>a</sup>	1.48	9.86 <sup>a</sup>	1.33
Yield of rump (%)	85.0	1.40	86.34	1.52	84.57	1.38	85.56	1.45

ZS – Złotnicka Spotted, D – Duroc, PLW – Polish Large White  
a, b – means with different superscripts are significant at  $p \leq 0.05$

with a 50% contribution of the Duroc breed. The yield of finished product did not differ significantly between groups and ranged from 84.57% to 86.34%. Olkiewicz et al. [11] obtained lower yield for dry-cured ham produced from pigs of the Złotnicka breed—on average 74.6%.

As in the case of the rump, the initial and final pH of the belly did not differ significantly between groups, ranging from 5.61 to 5.86 (Tab. 4). However, significant ( $p \leq 0.05$ ) differences between groups were noted in the weight increase of the belly during curing. Lower increases were noted in the crosses with a 25% share of the Duroc breed in comparison with the other groups (by about 3 p.p. on average). Weight loss in the belly after smoking was about 1 to 2 p.p. lower in this group as well. In spite of this, the yield of belly as a finished product was similar in all groups of animals (about 98% on average).

In terms of sensory characteristics, the dry-cured rump was rated very highly in all groups (Tab. 5). No significant differences were noted between groups for any of the sensory characteristics evaluated. For consistency, the rumps received about 4.90 points on a 5-point scale. Very good uniformity and desirability of colour were noted on the cross-section of the rumps of all groups (4.67 to 4.80 pts.).

**Table 4**  
Weight loss and pH of smoked bellies during processing

Studied trait	Breed group							
	ZS x ZS		ZS (ZS x D)		ZS x D		ZS x PLW	
	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd
pH initial	5.61	0.15	5.68	0.18	5.76	0.27	5.65	0.21
pH after smoking	5.78	0.09	5.86	0.06	5.83	0.17	5.78	0.11
Weight before curing (g)	954.5	186.6	1075.4 <sup>a</sup>	136.0	866.2 <sup>b</sup>	194.7	948.4	141.2
Weight gain after curing (%)	14.37 <sup>a</sup>	0.79	12.0 <sup>b</sup>	0.85	15.03 <sup>a</sup>	0.65	15.36 <sup>a</sup>	0.78
Weight loss after smoking (%)	13.43 <sup>a</sup>	0.85	12.68 <sup>b</sup>	0.80	14.74 <sup>c</sup>	0.72	14.33 <sup>c</sup>	0.69
Yield of belly (%)	98.9	0.30	97.8	0.35	98.1	0.40	98.8	0.33

ZS – Zlotnicka Spotted, D – Duroc, PLW – Polish Large White  
a, b, c – means with different superscripts are significant at  $p \leq 0.05$

**Table 5**  
Sensory traits, marbling (points), L\*a\*b\* colour parameters and NaCl content of the raw dry cured rumps

Studied trait	Breed group							
	ZS x ZS		ZS (ZS x D)		ZS x D		ZS x PLW	
	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd
Minolta L* (lightness)	42.31	3.20	42.38	4.13	43.38	3.80	44.84	3.07
Minolta a* (redness)	10.09	1.51	9.72	0.96	9.69	1.30	8.98	0.83
Minolta b* (yellowness)	4.19	1.54	4.05	1.45	4.21	1.77	4.39	2.12
Content of NaCl (%)	4.68	0.39	5.06	0.38	4.72	0.54	4.67	0.44
Consistency	4.93	0.08	4.92	0.07	4.91	0.12	4.90	0.08
Colour:								
compensation	4.67	0.17	4.60	0.26	4.61	0.30	4.67	0.20
desirability	4.80	0.18	4.68	0.22	4.67	0.33	4.69	0.18
Aroma	4.75	0.11	4.82	0.09	4.78	0.15	4.72	0.11
Juiciness	4.60	0.17	4.62	0.7	4.62	0.11	4.60	0.15
Tenderness	4.76	0.16	4.83	0.09	4.76	0.15	4.75	0.13
Palatability	4.81	0.16	4.85	0.15	4.88	0.11	4.78	0.10
Marbling	2.95	0.50	3.01	0.38	2.80	0.97	2.72	0.28

ZS – Zlotnicka Spotted, D – Duroc, PLW – Polish Large White

**Table 6**  
Characterization of fatness, sensory characteristics (points) and NaCl content of smoked belly

Studied trait	Breed group							
	ZS x ZS		ZS (ZS x D)		ZS x D		ZS x PLW	
	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd	$\bar{x}$	Sd
Thickness of fat layer (cm)	1.79	0.49	1.59	0.36	1.33	0.60	1.24	0.54
Thickness of lean layer (cm)	1.57	0.62	1.68	0.48	1.78	0.59	1.81	0.26
Ratio of fat and lean layers	1.39 <sup>a</sup>	0.87	1.01 <sup>a,b</sup>	0.33	0.83 <sup>b</sup>	0.42	0.77 <sup>b</sup>	0.34
Content of NaCl (%)	4.87	0.39	4.78	0.35	5.18	0.45	5.09	0.38
Consistency	4.64	0.20	4.66	0.12	4.66	0.11	4.7	0.17
Colour:								
compensation	4.58	0.22	4.48	0.23	4.65	0.13	4.67	0.14
desirability	4.67	0.20	4.53	0.16	4.75	0.10	4.74	0.20
Aroma	4.62	0.13	4.73	0.17	4.75	0.13	4.65	0.11
Juiciness	4.64	0.13	4.75	0.11	4.71	0.12	4.68	0.10
Tenderness	4.19	0.20	4.18	0.13	4.24	0.29	4.15	0.17
Palatability	4.48	0.17	4.54	0.21	4.49	0.18	4.47	0.27

ZS – Złotnicka Spotted, D – Duroc, PLW – Polish Large White  
a, b – means with different superscripts are significant at  $p \leq 0.05$

These observations were confirmed by the instrumental measurements of lightness of colour, which did not differ significantly ( $42.31 < L^* < 44.84$ ). Moreover, the rump received high scores for juiciness (on average 4.6 pts.), palatability (4.78-4.81 pts.) and tenderness (4.75-4.83 pts.). Olkiewicz et al. [11] obtained a similar result for lightness of colour for dry-cured ham produced from the meat of Złotnicka pigs, at  $L^* = 47.7$ , as well as a high sensory evaluation.

The sensory evaluation of the smoked bacon showed that it was of high quality, which did not differ significantly between groups (Tab. 6). Good uniformity and desirability of meat colour was observed on the cross-section of the belly of all groups. The consistency, juiciness, palatability and tenderness of the product were very favourable (on average 4.6 pts., 4.7 pts., 4.5 pts. and 4.2 pts.). The tenderness of the products was also linked to the fact that no exudative meat was noted in any of the genetic groups of pigs.

To determine the degree of fatness of the smoked belly, the ratio of the thickness of the fat layer to that of the meat layer was calculated (Tab. 6). This ratio proved highest in the purebred Złotnicka pigs (1.39 vs 0.77 to 1.0), which indicates that these individuals had greater fat cover.



To sum up, the results obtained indicate that crossbreeding of Zlotnicka Spotted pigs using the Duroc and LPW breeds caused an increase in the meat content of the carcasses and a decrease in backfat thickness, but only in the case of crosses with a 50% share of the two breeds. In all genetic groups studied the meat obtained was of very good quality, with no quality defects. The quality of the meat products prepared from the meat of the analysed groups of pigs did not differ significantly in terms of physicochemical characteristics (pH or lightness of colour) or organoleptic traits. Weight loss in the rump during the curing process did not differ significantly between groups. However, the weight loss during smoking was lower in the crosses with a 25% contribution of the Duroc breed (by about 1 p.p.). At the same time, in this group the increase in the weight of the belly during curing and the loss in weight during smoking were lower than in the other groups.

To improve the carcass value of fattening pigs of the Zlotnicka Spotted breed, particularly the meat content of the carcasses, crossing of this breed with the LPW breed is more efficient than crossbreeding with the Duroc breed, while the quality of the products prepared from the meat of the crosses does not differ significantly in comparison with purebred Zlotnicka Spotted pigs.

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