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THE EFFECT OF CROSSING THE NATIVE ZŁOTNICKA SPOTTED PIGS WITH OTHER BREEDS ON SLAUGHTER VALUE OF FATTENERS AND QUALITY OF DRY-CURED MEAT PRODUCTS

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Abstract

The dry-cured necks and hams produced from the meat of Złotnicka Spotted (ZS) pigs and their crossbreds with Duroc and Polish Large White, were tested. The slaughter value of the fatteners was determined (lean meat content, backfat thickness, area of the loin cross-section). The water, fat, protein and NaCl content was established in the final products. The meat colour (L* a* b*) and pH were measured. The final products were subjected to sensory evaluation and ranked on the scale of 1–5 points. Crossing the Złotnicka Spotted with the PLW resulted in higher lean meat content by approx. 4 percentage points (p.p.) and in thinner back fat thickness by 0.6 cm. Dry-cured ham produced from the meat of different fattener groups did not differ significantly in terms of physico-chemical traits as well as sensory traits. The sensory characteristics of both ham and neck received high scores (on average above 4.5 points). It was found that the tested products differed in terms of chemical content. The dry-cured necks contained approx. 19.45% of fat in the group of the ZS × PLW crossbreds whereas in other groups this figure was 2 to 6 p.p. higher. The dry-cured ham that was produced was based on the meat of purebred pigs containing 3 to 4.6 p.p. less fat compared to the crossbreds with the Duroc. The research proved that crossing the ZS with PLW and Duroc did not make the quality of the dry-cured products deteriorate.

Key words: pigs, breeds, slaughter value, product quality

Today consumers are looking for pork products of good quality. This makes meat processors look for fatteners with the desired quality. In many countries such a desired quality is provided by old native breeds which are protected. A good example of this can be found in Italy where there are 5 local rare breeds, including the Casertana breed of ancient origin or primitive Sarda breed (Salvatori et al., 2008). The carcasses of these breeds have thick backfat and their meat is appreciated because of its favourable taste. This meat is used especially for Parma ham production. In Spain the local Iberian breeds such as Celta or Chato Murciano pigs are chosen for the production of dry-cured products (Poto et al., 2007; Pugliese and Sirtori, 2012; Ventanas et al., 2006). In France special attention should be paid to the Pi Noir du Pays Basque rare breed, which is used for producing Basque ham (Szulc, 2010). Pugliese and Sirtori (2012) have analysed rare breeds from the South of Europe including the influence of genetic traits and production systems on the product quality. They found that rare breeds have lower productive performance and lower lean meat content than commercially produced breeds. But the meat of the rare breeds is of better quality. Pugliese et al. (2015) tested the ham (*bicep femoris* and *semimembranosus* muscles) called Kraški pršut, a type of the Slovenian dry-cured ham, after 12 and 16 months of maturing. In both muscles the basic chemical content was determined together with the meat texture as well as the fatty acids and the volatile substances levels were also established. The authors showed significant differences in the studied traits between the two muscles as well as between different maturing times.

The rare Polish breeds are Złotnicka Spotted, Złotnicka White and Puławska. The population of Złotnicka pigs has a unique genetic value. Their slaughter value, especially lean meat content, is lower than that of the commercial breeds mainly because of their tendency to accumulate more fat in comparison with other breeds (Grześkowiak et al., 2010; Kapelański et al., 2006; Żak et al., 2008; Żak and Tyra, 2006). These breeds are less suitable for meat production mainly because of the low lean meat content (Grześkowiak et al., 2009; Kapelański, 2006).

The production results of the rare breeds might be improved by crossing them with other breeds (Szulc et al., 2006; Żak and Pieszka, 2009). In order to prevent the meat from losing its quality, it is very important to carefully choose the breed that could be crossed with the Złotnicka. Because of the favourable meat quality traits the most suitable breeds to be crossed with the Złotnicka seem to be the Duroc and PLW. The Duroc breed, regarded as being free from the stress gene, produces meat that is of a similar quality to the meat of the PLW pigs (Migdał et al., 2007).

The goal of this study was to determine the effect of crossing the Złotnicka Spotted with the Duroc and PLW boars on the slaughter value of the fatteners and the quality traits of the chosen meat products, i.e. dry-cured (raw maturing) neck and ham.

Material and methods

The research material was 50 fatteners selected from a farm in Jaworowo near Gniezno and they were divided into 4 genetic groups (Table 1). The criterion of the division in the experimental design was the crossing of Złotnicka Spotted with the Duroc and PLW pigs.

In all of the groups the gilt to castrate ratio was 1:1. Each group of fatteners was kept in the group pens with *ad libitum* feeding. The feed mixture rations are given in Table 2. The feeding and management conditions were the same in all of the groups.

Table 1. The design of experiment

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

Table 2. Proximate composition of diet

Item	Diet		
	starter	grower	finisher
Dry matter	90.29	90.28	90.56
Energy (MJ/kg)	13.46	12.63	12.46
Crude protein (%)	16.26	17.31	14.79
Digestible energy (%)	13.65	14.65	12.65
Crude fibre (%)	3.45	4.16	3.90
Crude fat (%)	3.58	1.95	2.01
Ash (%)	4.73	4.98	4.77
Ca (%)	0.81	0.78	0.77
P (%)	0.67	0.62	0.61
Lysine (%)	1.11	0.99	0.79
Spring barley (%)	26.00	20.00	21.00
Triticale (%)	-	20.00	39.80
Winter wheat (%)	30.40	16.10	-
Maize (%)	20.00	13.00	12.00
Soybean meal 46 (%)	16.00	13.00	7.40
Rapeseed meal "00" 34 (%)	-	5.00	2.00
Wheat bran (%)	-	10.00	15.00
Ekonomix T[1] (%)	2.40	1.50	1.30
Ground limestone (%)	1.10	1.40	1.50
Zinteral[2] (%)	0.10	-	-
Substimel 950[3] (%)	4.00	-	-

[1]Mineral feed.
[2]Zn additive.
[3]Whey additive.

The pigs were slaughtered at 120 kg of live weight using the same slaughtering technique (electric stunning, bleeding in the hanging position, cooling with the one stage method). The warm, hanging left carcasses were measured for lean meat content using the UltraFom 300 instrument (Borzuta et al., 2004). In addition, the backfat was measured above the shoulder, on the back behind the last rib and on the ham, i.e. at the beginning of the ham (cross I), in the middle (cross II), and at the end of the *gluteus medius* muscle (cross III). The area of the loin cross-section was measured between the 12th and 13th dorsal vertebrae. The samples of the fresh *semimembranosus* muscle (24 h *postmortem*) from the left carcasses were subjected to basic chemical analysis as were the samples from the right carcasses of the same pigs used for the dry-cured products.

The dry-cured products were made from the upper part of the ham (the main muscle was the *semimebranosus* muscle) and the neck without bones (the main muscles were the *longissimus cervicis*, *trapezius*, *rhomboideus*, *sternocephalicus*).

The neck and ham muscles were cured with a dry mixture of curing substances and spices in a room at a temperature of 6–8°C and relative humidity 85–90%. The composition of the mixture was as follows: curing salt (80%), starting culture Pökelferment 77 special (0.5%), sucrose (6%), glucose (6.4%), juniper (2%), allspice (1.5%), natural bay leaf (2%), natural black pepper (2.1%). The composition of the curing salt was: common salt without iodine (78.3%), rock salt without iodine (20.35%), sodium nitrate (1.05%), sodium nitrite (0.3%). The muscles were mixed with the curing-spices mixture in a vacuum slowly rotating tumbler for 5–10 minutes while adding 47 g of the mixture to 1 kg of meat. In the next step the muscles were put closely in boxes and were turned 3 times every 3 days adding 5 g of the salt mixture per kg of meat. The curing time for both products was 14 days and maturing lasted a total of 30 full days. After curing, the muscles were put on shelves in the maturing room for 10 days. The temperature in the maturing room was 10 to 12ºC, and the relative humidity of the air was approx. 80%. After the maturing process the hams and the necks without bones were smoked in a smoking chamber in three stages: stage 1 – drying for 12 h without smoke, in the air temperature of approx. 25°C and relative humidity of approx. 80%, stage 2 – drying for 24 h without smoke in the air temperature of approx. 18°C and relative humidity of 70%, stage 3 – smoking up to 6 h with cold smoke at a temperature of 20°C and relative humidity of 70%. After smoking the final product was kept in the maturing room for 5 full days at a temperature of 10–12°C and 75% relative humidity up to the moment when product yield reached 76%.

The pH was measured with a pH meter (Model 1140 Mettler Toledo) and electrode (Mettler Toledo, Germany). The measurements were taken on the *semimembranosus* muscle (SM) and on the neck muscles before processing (pH_{24}) as well as during the production process.

The samples of the final products were taken for lab analysis. The water content was measured according to the ISO 1442 (2000). Approx. 3 g of the minced meat was put on the weighing dish, weighed and dried at a temperature of 105ºC up to the moment when the stable mass was reached. The water content expressed in % was calculated as a difference between the sample weight before and after drying.

The intramuscular fat content was established according to the ISO 1444 (2000) procedure. The dried and weighed sample was placed in an extraction tube and the fat substances were extracted with paraffin oil in a Soxtherm device (Gerhardt Laboratory Systems). The fat content was calculated as the difference between the sample weight before and after extraction. The protein content was established according to the Polish norm PN/A-04018 with the Kjeltec System 1002 Distilling Unit method. The sodium chloride in the final products was established according to the ISO 1841-2 (2002) procedure.

The fresh muscles were weighed on an electronic scale with 1 g accuracy after curing and after maturing. The dynamics of the muscle loss in the production process was determined after 10, 20 and 30 days of curing. At the same time and on the same days the pH was measured in the muscles. After the production process the yield of the final product was calculated.

The colour was evaluated using a CR 400 Chroma Meter (Konica Minolta, Tokyo, Japan). L*a*b* parameters were measured (the source of light D65, observer 2°, the opening of the measuring head – 8 mm, calibration on the white standard: L*–97.83, a*–0.45, b*–1.88).

The sensory evaluation of the final products was done by a team of 5 people who tested the samples for their sensory sensitivity (Baryłko-Pikielna and Matuszewska, 2014). The evaluation was done in daylight at a temperature of 20±2°C, on the samples of the meat of thickness of approx. 2–3 mm. The meat colour in the final product (compensation and colour desirability), flavour, juiciness, tenderness and palatability were evaluated on a 5 point scale (ISO 4121 (1998); NPPC, 1991). The following evaluation scale was used: colour compensation: 1=very low compensation; 5=very high compensation; colour desirability 1=very undesirable; 5=very desirable. Flavour: 1=very unacceptable; 5=very acceptable; juiciness 1=very dry; 5=very juicy; tenderness 1=very tough; 5=very tender; palatability 1=very unacceptable; 5=very acceptable.

The obtained results were analysed statistically for the mean values and the standard error of the mean (SEM). Statistical significance of the differences between the mean values of the groups was verified using a single factor variance analysis as well as using the Tukey test and Statistica Pl V.9.1 software.

Results

The effects of the crossing were observed on the lean meat content as well as on the loin cross-section area (Table 3). The highest lean meat content was noticed in the crossbreds of the ZS with the PLW. The crossing with the Duroc did not cause any significant increase in the lean meat content but it had a significant effect on the increase of the loin cross-section area ($P \leq 0.01$) by approx. 6 to 7 cm^2.

The effect of the genetic group on backfat thickness was also observed. The thickest average backfat layer measured in 5 points was observed in the fatteners with 25% share of the Duroc genes (group ZS × (ZS × D). It was 0.9 cm more than observed in the ZS × PLW group. The differences between these groups in backfat thickness measured at some measurement points (i.e. over the shoulder, on the crosses I and II) were found to be significant ($P \leq 0.05$). The purebred fatteners' backfat thickness was similar to the backfat thickness of the ZS × (ZS × D) group. Whereas the backfat thickness of fatteners from the ZS × D group was similar to the ZS × PLW group that had a higher lean meat content.

Table 3. Slaughter value of Złotnicka Spotted pigs and their hybrids

Trait	Groups				SEM	P
	ZS × ZS	ZS × (ZS × D)	ZS × D	ZS × PLW		
Hot carcass weight (kg)	88.92	90.57	88.57	87.26	5.90	0.79
Meat content (%)	43.99 a	42.47 a	45.02 a	48.00 b	4.01	0.04
Loin eye area (cm²)	29.61 A	36.63 B	35.24 B	35.97 B	5.72	0.01
Backfat thickness (cm):						
over shoulder	5.42	6.08 a	5.35	4.70 b	0.72	0.05
over last rib	3.13	3.29	2.87	2.72	0.65	0.16
on cross I	4.40	4.45 b	3.88	3.61 a	0.66	0.02
on cross II	3.63	3.92 b	3.20	3.04 a	0.67	0.04
on cross III	4.54	4.82	4.00	3.96	0.77	0.07
Backfat thickness of five measurements (cm)	4.22	4.51 b	3.86	3.61a	0.60	0.03
Moisture content of SM (%)	71.30 a	70.31 b	70.74	70.64	0.80	0.03
Fat content of SM (%)	2.25 a	2.79	2.89 b	2.90 b	0.56	0.01
Protein content of SM (%)	25.10	25.61	25.07	25.16	0.96	0.62

Explanatory notes:
Meanings of group symbols as in Table 1 mean value.
a, b, c – mean values in rows and denoted by different letters differ statistically significantly at P≤0.05.

Table 4. Weight losses and pH of raw maturing ham during processing

Traits	Groups				SEM	P
	ZS × ZS	ZS×(ZS×D)	ZS × D	ZS × PLW		
Weight of raw muscle (g)	1388.06	1502.83	1466.38	1440.63	176.33	0.12
Losses after 10 days of curing (%)	1.66	0.92	1.36	1.49	1.48	0.21
Losses after 20 days of curing (%)	10.85	9.58	12.04	12.32	2.10	0.25
Losses after 30 days of curing (%)	22.5	20.71	21.93	23.15	3.23	0.31
Yield of product (%)	76.18	77.91	76.60	75.37	2.47	0.29
pH of raw muscle	5.79	5.87	5.74	5.71	0.14	0.51
pH after 10 days	5.81	5.69	5.66	5.62	0.07	0.08
pH after 20 days	5.81	5.69	5.65	5.60	0.09	0.11
pH after 30 days	5.74	5.62	5.66	5.58	0.08	0.25

In the process of production of ham no significant differences were found between the groups in terms of technological parameters. Products' pH was similar at each production stage and did not differ significantly between the studied groups (Table 4). No significant differences were found in the mass losses of the final products from the different genetic groups at all of the studied production stages. It was noticed that the longer the curing and maturing time the higher the mass losses. The yield of the final products did not differ significantly between the groups. In the case of the neck production process (Table 5) significant differences were found only in weight losses after 20 days of curing (lower in ZS × (ZS × D) and ZS × PLW groups), yield of product (lower in ZS × ZS and ZS × D groups) and pH of raw muscles (lowest value in ZS × PLW group). In addition, increase of pH value after 30 days of curing could be probably explained by more fat content in neck than in ham.

Table 5. Weight losses and pH of raw maturing deboned neck during processing

Traits	Groups				SEM	P
	ZS × ZS	ZS× (ZS×D)	ZS × D	ZS × PLW		
Weight of raw muscle (g)	1462.15	1500.12	1399.14	1487.10	177.91	0.62
Losses after 10 days of curing (%)	0.99	0.49	1.64	0.57	0.86	0.09
Losses after 20 days of curing (%)	13.03 a	10.85 b	12.84 a	11.41 b	0.99	0.04
Losses after 30 days of curing (%)	24.75	22.21	24.49	23.54	1.05	0.25
Yield of product (%)	75.24 A	77.79 B,a	75.50 A	76.46 b	1.04	0.04
pH of raw muscle	5.91 a	5.97 a	5.93 a	5.79 b	0.19	0.03
pH after 10 days	5.74	5.88	5.88	5.78	0.10	0.12
pH after 20 days	5.62	5.75	5.84	5.75	0.07	0.08
pH after 30 days	5.92	6.02	6.02	5.94	0.12	0.17

A, B – mean values in rows and denoted by different letters differ statistically significantly at P≤0.01.
a, b – mean values in rows and denoted by different letters differ statistically significantly at P≤0.05.

Table 6. The physico-chemical and sensory traits of raw maturing ham

Trait	Groups				SEM	P
	ZS × ZS	ZS × (ZS ×D)	ZS × D	ZS × PLW		
Moisture content (%)	50.35 A	45.54 B	45.07 B	49.58 A	4.34	0.01
Fat content (%)	14.55 a	17.55 b	19.14 b	15.56 a	4.27	0.05
Protein content (%)	27.23 a	29.15 b	29.02 b	27.47 a	1.86	0.02
NaCl content (%)	6.15 A	6.26 A	5.70 B	6.18 A	0.29	0.01
L* (lightness)	37.66	38.64	38.74	38.28	2.46	0.62
a* (redness)	11.26	9.14	9.21	10.01	1.05	0.08
b* (yellowness)	1.80	1.62	1.55	1.60	0.75	0.06
Colour compensation (score)[1]	4.34	4.42	4.50	4.48	0.17	0.08
Colour desirability (score)[2]	4.49	4.53	4.55	4.56	0.13	0.55
Flavour (score)[3]	4.49	4.59	4.61	4.54	0.11	0.06
Juiciness (score)[4]	4.24	4.32	4.40	4.30	0.16	0.08
Tenderness (score)[5]	4.50	4.49	4.59	4.54	0.12	0.18
Palatability (score)[6]	4.61	4.64	4.71	4.64	0.15	0.50

[1]scale 1 (very low compensation) to 5 (very high compensation).
[2]scale 1 (very undesirable) to 5 (very desirable).
[3]scale 1 (very unacceptable) to 5 (very unacceptable).
[4]scale 1 (very dry) to 5 (very juicy).
[5]scale 1 (very tough) to 5 (very tender).
[6]scale 1 (very unacceptable) to 5 (very unacceptable).
A, B – mean values in rows and denoted by different letters differ statistically significantly at P≤0.01.
a, b – mean values in rows and denoted by different letters differ statistically significantly at P≤0.05.

The basic chemical composition of ham differed significantly between the groups (Table 6). The crossbreds with the Duroc gave a product with approx. 5 p.p. less water, 2–4 p.p. more fat and approx. 2 p.p. more protein than the purebred ZS or crossbreds of the ZS × PLW. It was not caused by the chemical composition of the raw meat before curing (Table 3) but rather by the production processes. In the production process the water content in the ham decreased (by 20 to 26 p.p.) and the fat content increased by almost 6 times whereas in the fresh ham these numbers were on average 70% of water and 2–2.9% of fat (Table 6).

In the studied groups the pH of the raw *musculus semimembranosus* and muscle pH during processing remained at a similar level (approx. 5.7). The colour parameters L*a*b* did not differ significantly between the groups. Whereas the ham muscles of the crossbreds of the ZS with 50% of the Duroc diffused less salt (5.70%) compared to other groups. This could be related to the higher fat content found in the final product (19.14%).

The lower average pH value before curing was observed in the neck muscles from the ZS × PLW ($P \leq 0.05$) group. The final pH of the ready product did not differ significantly between the groups (Table 5). After 20 and 30 days of the curing and maturing process the higher mass losses were observed in the muscles of the Złotnicka pigs and its crossbreds with 50% of the Duroc. That was why the final products in these groups were of lower yield comparing to the other groups.

Table 7. The physical-chemical and sensory traits raw maturing deboned neck

Trait	Groups				SEM	P
	ZS × ZS	ZS × (ZS×D)	ZS × D	ZS × PLW		
Moisture content (%)	47.59 a	44.37 b	44.22 b	47.86 a	3.36	0.03
Fat content (%)	21.37 a	25.97 b,B	24.86 b	19.45 a,A	3.63	0.00
Protein content (%)	23.39	22.41	24.14	25.34	2.39	0.22
NaCl content (%)	6.12	6.50	6.01	6.49	0.37	0.30
L* (lightness)	36.33	38.04	38.06	39.47	2.62	0.26
a*(redness)	12.22	14.32	14.42	11.60	1.73	0.08
b*(yellowness)	1.82	3.54	3.60	1.75	0.85	0.07
Colour compensation (score)[1]	4.46	4.47	4.35	4.47	0.16	0.24
Colour desirability (score)[2]	4.59	4.58	4.51	4.64	0.18	0.43
Flavour (score)[3]	4.64	4.63	4.55	4.58	0.13	0.35
Juiciness score)[4]	4.47	4.43	4.42	4.24	0.11	0.08
Tenderness (score)[5]	4.61	4.56	4.56	4.58	0.12	0.60
Palatability (score)[6]	4.67	4.47	4.52	4.62	0.10	0.07

[1]scale 1 (very low compensation) to 5 (very high compensation).
[2]scale 1 (very undesirable) to 5 (very desirable).
[3]scale 1 (very unacceptable) to 5 (very acceptable).
[4]scale 1 (very dry) to 5 (very juicy).
[5]scale 1 (very tough) to 5 (very tender).
[6]scale 1 (very unacceptable) to 5 (very acceptable).
a, b – mean values in rows and denoted by different letters differ statistically significantly at $P \leq 0.05$.
A, B – mean values in rows and denoted by different letters differ statistically significantly at $P \leq 0.01$.

The basic chemical content of the neck is presented in Table 7. Significant differences were observed in the intramuscular fat content. In the neck of the crossbreds with the Duroc approx. 3.5 p.p. to 4.5 p.p. more fat was found than in the neck of the Złotnicka pigs and its crossbreds with the PLW, which is connected with differences in moisture content.

Like in the ham, the colour lightness L* and colour compensation and desirability were similar in the investigated groups and did not differ significantly. The sodium chloride content in the different groups was rather stable and ranged from 6.01 to 6.50%. So the higher fat content in the necks of some of the groups did not cause significant differences in the salt content in the final product.

The dry-cured ham of all of the research groups received high scores in the sensory tests. No significant differences were found between the groups in all of the tested sensory indicators. On the hams' cross-sections a very good compensation and desirability of the colour was found. These observations were confirmed by the colour lightness in the instrumental measurements of L* (Table 6). The ham tenderness evaluated in the sensory test was very favourable in all of the experimental groups. What is more, the ham received high scores for juiciness and palatability.

Like the dry-cured ham, also the dry-cured neck obtained high scores in the sensory tests. The evaluated indicators did not differ significantly between the groups. Both colour compensation and desirability were given average scores in the different groups ranging from 4.35 to 4.64 points. The desired colour of the neck was also confirmed by the instrumental measurements of the L*a*b* parameters, among which special attention should be paid to the high number of the red tone (approx. 12–14). The average score of neck tenderness, juiciness and palatability was in the range between 4.47 and 4.67 points and did not differ significantly between the groups. In conclusion it must be stated that the results of sensory test are shown as a preliminary study because there was no consumer test done. The experimental production was conducted on too small a scale to provide a more comprehensive consumer analysis.

Discussion

Crossing the Złotnicka pigs with the PLW caused a higher lean meat content and lower backfat thickness. The backfat thickness in the ZS × PLW group decreased on average by 0.6 cm whereas the lean meat content increased by approx. 4 p.p. In the experiment on the Złotnicka White crossed with the PLW done by Strzelecki et al. (2006), similar effects were observed, i.e. lean meat increased from 46.4 to 49.7%. What is more, the loin cross-section area increased from 36.2 to 42.2 cm^2 whereas the backfat thickness decreased from 4.1 to 3.1 cm. A better effect was observed in the research on the ZS crossing with Pietrain pigs. Wajda and Meller (1996) in the sample of crossing (ZS × PI) obtained fatteners with an average of 53.2% lean meat content. This group of fatteners differed in a larger area of the loin cross-section and a thinner backfat layer. Increasing the share of Pietrain breed in the crossbreds up to 75% caused further improvement of the slaughter traits. In spite of these effects crossing the Złotnicka with the Pietrain breed is still risky because it may increase the risk of PSE meat in the crossbreds. The authors proved that the first generation of fatteners showed traits that were close to the traits of the Złotnicka pigs whereas the second generation of fatteners revealed traits close to those of the Pietrain breed (Wajda and Meller, 1996). Other authors have reported also low levels of the lean meat content in the Złotnicka carcasses reaching 43.5 to 46% (Grześkowiak et al., 2009; Kapelański et al., 2006).

The increased mass losses in the production process of the dry-cured ham and neck were caused by the rate of salt and water ion diffusion which were determined by external factors (among others: sodium chloride and curing substances concentration, temperature and the length of the processing period) and the internal factors such as: morphological state, chemical and biochemical state of the muscles (Fox, 1980; Lautenschlager, 1995, 1996; Ockerman and Kwiatek, 1985; Tyszkiewicz and Kłosowska, 1998). Olkiewicz et al. (2006) reported an average yield of 74.6% (similar to that obtained in our study) for the dry-cured ham produced from the meat of the Złotnicka breed.

The changes in the basic chemical composition of ham were connected with the water losses during the production process and with an increase in the salt concentration in the meat. These two facts caused, among others, changes in the chemical composition and the tissue structure of the meat, physical and chemical state of proteins, and permeability of the cellular membranes (Fox, 1980; Palmia and Bolla, 1991).

The colour of dry-cured hams and necks, their colour compensation and its permanency are all very important quality indicators. The pH of raw meat has a great influence on colour compensation and desirability as well as on its further changes during the process of producing dry-cured hams (Arnau et al., 1998; Pérez-Alvarez et al., 1997). The curing substances, both nitrates and nitrites, are responsible for obtaining the desirable and permanent red colour (Kłosowska and Tyszkiewicz, 2000). Nitrites after their reduction to nitrogen oxide combine with myoglobin to form nitrosylmyoglobin which is responsible for the characteristic colour of the cured meat. As the supplies of the introduced nitrites are used up, the nitrates are slowly reduced into the nitrites. In the maturing process they contribute to the desired colour and its permanency during storage of the final product.

In conclusion, crossing the Złotnicka Spotted pigs with the Duroc and PLW resulted in an increase of the lean meat content as well as a decrease of the backfat thickness but only for the crossing with the PLW. The crossing did not have any effect on the technological parameters of the raw maturing ham production process, i.e. pH, mass loss and the technological yield. The quality of the final products produced and based on the meat of the experimental animals did not differ significantly ($P \leq 0.05$) in terms of the physical and chemical traits (pH, colour lightness) as well as the sensory traits. The tested meat products differed in terms of their chemical composition. The hams and necks with the lowest fat content were obtained from the Złotnicka purebred pigs and their crossbreds with the PLW breed.

This paper has been proof-read by a native speaker of English who is a Senior Lecturer (TEFL) at the Adam Mickiewicz University, Poznań.

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