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Culinary and technological suitability of pork obtained from three-way cross fatteners (Landrace x Yorkshire) x Duroc and (Landrace x Yorkshire) x Hampshire

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The aim of the study was to evaluate the culinary and technological value of meat obtained from three-way cross fattening pigs, i.e. [Landrace (L) x Yorkshire (Y)] x Duroc (D) and [Landrace (L) x Yorkshire (Y)] x Hampshire (H). The study was carried out in spring and summer on 60 pigs divided in 2 genetic groups: (LxY) x D and (LxY) x H. The rearing and pre- and post-slaughter conditions were the same for all animals. Slaughter and post-slaughter handling of the carcasses was in accordance with the procedure in use at the meat plant. The research material was similar in terms of hot carcass weight (85.14 ±2.90 kg and 85.31 ±3.29 kg) and lean meat content (56.50 ±2.71% and 56.98 ±1.99%) within each genetic group, i.e. (LxY) x D and (LxY) x H. The significant, highly unfavourable means obtained for meat quality traits in the case of the (LxY) x H pigs, in terms of both culinary and technological suitability for processing, clearly indicates that the Hampshire breed should not be used as a paternal component in mass production of fatteners. In the case of the (LxY) x D fatteners, the highly favourable values for meat quality traits, of importance to both the consumer and the meat industry, clearly support the use of the Duroc breed as a paternal component.

KEY WORDS: fatteners / crossbreds / meat quality / culinary suitability / technological suitability

Changes in the lifestyle of meat consumers in Poland and other parts of the world are associated with changes in the expectations of the market for meat and its products [28]. Breeding work carried out in the second half of the 20th century, aimed mainly at improving the fattening and carcass characteristics of pigs, also had a negative effect, i.e. a deterioration in the quality of the raw material obtained, in terms of use for both culinary and processing purposes [9, 21]. Two aspects of meat quality should be considered. The first concerns the quality of raw meat for cooking, and the second is the quality and technological suitability of the raw material for further processing [1, 2].

High quality pork can be obtained through skilful selection of breeds for cross-breeding, mainly paternal components [9, 24, 26, 27]. Duroc pigs are considered to have exemplary meat quality traits, including optimal intramuscular fat content acceptable to the consumer. Pigs of this breed have been used in breeding programmes in most European countries for many years [3, 9, 25, 29]. Hampshire pigs show a genetic tendency to produce acid meat after slaughter, because this population is burdened with the RN^- gene. The occurrence of acid meat causes significant losses during cooking [9, 12, 16, 22, 23, 27]. The share of the Hampshire breed among assessed breeding sows in 2016 was 0.2% [30].

The aim of the study was to evaluate parameters of the culinary and technological value of three-breed crosses with Duroc and Hampshire on the paternal side, i.e. (Landrace x Yorkshire) x Duroc and (Landrace x Yorkshire) x Hampshire.

Material and methods

The research was conducted in the spring and summer on 60 crossbred fattening pigs belonging to two genetic groups (30 pigs per group, with an equal share of males and females in each group): [(Landrace (L) x Yorkshire (Y)] x Duroc (D) and [(Landrace (L) x Yorkshire (Y)] x Hampshire (H). The parent material was from a Danish breeding farm, except for the Hampshire breed, which came from a Polish breeding facility. The housing, feeding (complete rations according to age) and pre-slaughter handling conditions were the same for all pigs. The pigs were slaughtered 2-4 h after transport (300 km) by electric stunning (INARCO system) and bleeding in a horizontal position, according to the technology in use at the meat plant. The hot carcass weight (HCW) was determined to the nearest 0.1 kg 35 minutes after slaughter on a track scale. The meat content in the carcass was estimated using an ULTRA-FOM 300 ultrasound apparatus from the Danish company SFK Technology. The research material was similar in all groups in terms of HCW, i.e. 85.14 ± 2.90 kg for (LxY) x D and 85.31 ± 3.29 kg for (LxY) xH, and the percentage content of meat in the carcass – 56.50 ± 2.71% for (LxY) x D and 56.98 ± 1.99% for (LxY) x H.

Meat quality was evaluated after slaughter in the longissimus lumborum muscle (LL), based on the following parameters:

– muscle tissue acidity (pH)
– lightness of colour (L*)
– drip loss (DL)
– weight lost in vacuum-packed meat (VAC)
– weight lost in modified atmosphere packaged meat (MAP; portioned and packaged in a modified atmosphere of gases, i.e. 75% CO_2 and 25% O_2)
– technological yield of cured meat (TY)

The pH was measured in the LL muscle tissue 45 min (pH_{45}), 24 h (pH_{24}), 48 h (pH_{48}), 96 h (pH_{96}) and 144 h (pH_{144}) post mortem, using a Dramiński MASTER pH meter with a spear tip electrode. The lightness (L*) of the LL muscle colour was determined 24 h after slaughter with a Minolta CR 310 apparatus. Drip loss was determined according to Prange et al. [20] at 48 h (DL_{48}), 96 h (DL_{96}) and 144 h (DL_{144}) after slaughter. Weight lost in vacuum-packed and MAP meat was determined 48 h, 96 h and 144 h after slaughter according to the methods used at the production plant. TY was determined according to Neveau et al. [16], with a modification by Koćwin-Podsiadła et al. [9]. In addition, the proximate composition of samples taken from the LL muscle was determined: content of water and dry matter according to PN-ISO 1442:2000 [19], total protein by the Kjeldahl method according to PN-75/A-04018 [17], and intramuscular fat (IMF) by the Soxhlet method, according to PN-ISO 1444:2000 [18].

Based on the threshold values presented in Table 1 for meat quality parameters, i.e. pH_{45}, pH_{24} and pH_{48}, four meat quality classes were distinguished: RFN – reddish-pink, firm, non-exudative; PSE – pale, soft, exudative; DFD – dark, firm, dry; and AM – acid meat.

Table 1

Threshold values for selected meat quality parameters [10, 11, 32]

Parameter	RFN	PSE	AM	DFD
pH_{45}	≥6,0	<6,0	≥6.0	≥6.0
pH_{24}	5.6-5.7	5.5-5.6	–	≥6.0
pH_{48}	–	–	≤5.4	–

In addition, based on the drip loss from the LL muscle at 48 h post mortem, adopting the threshold value given by Bertram et al. [5] for DL_{48} = 4.0%, two quality classes were distinguished: I – non-exudative meat (DL_{48} ≤ 4.0%), II – exudative (dripping) meat (DL_{48}> 4.0%).

The results were analysed statistically using the Statistica 12.5 PL statistics package (StatSoft, Tulsa, USA). The level of significance of differences between means for groups was verified by Student's t-test [14]. The frequency of pork quality classes was calculated as a percentage of each genetic group, as well as for the entire research material.

Results and discussion

In the research material, the genetic group differentiated all analysed quality traits of meat except for lightness (L*). The quality of the meat of pigs from the two genetic groups, i.e. (LxY) x D and (LxY) x H, differed greatly, with inferior traits found in the group with a contribution of Hampshire. The differences between groups were confirmed statistically (at P≤0.01) in the case of all meat quality traits tested, except for lightness (L*) – Table 2.

Analysis of the muscle tissue of the two genetic groups of pigs in terms of nutritional value, expressed as proximate composition (content of water, dry matter, protein and intramuscular fat), revealed markedly better results for crossbreds including the Duroc breed. The meat of (LxY) x D pigs had lower water content than that of (LxY) x H pigs (72.73% vs. 74.62%), and higher content of dry matter (27.27% vs. 25.38%), protein (23.50% vs. 22.63%) and intramuscular fat (IMF) – 2.20% vs. 1.20% (Table 2). The 2.20% IMF con-

Table 2
The influence of genetic group on culinary and technological meat quality traits

Trait	Genetic group (LxY) x D n=30	Genetic group (LxY) x H n=30	Total n=60
Water content (%)	72.73^{A} ±0.93	74.62^{B} ±0.70	73.68 ±1.25
Dry matter content (%)	27.27^{B} ±0.91	25.38^{A} ±0.70	26.32 ±1.24
Total protein content (%)	23.50^{B} ±0.91	22.63^{A} ±0.89	23.06 ±0.91
Intramuscular fat content (%)	2.20^{B} ±0.81	1.20^{A} ±0.36	1.69 ±0.79
pH_{45}	6.57^{B} ±0.15	6.45^{A} ±0.21	6.51 ±0.19
pH_{24}	5.74^{B} ±0.10	5.59^{A} ±0.08	5.67 ±0.12
pH_{48}	5.52^{B} ±0.09	5.34^{A} ±0.07	5.43 ±0.12
pH_{96}	5.61^{B} ±0.09	5.37^{A} ±0.07	5.50 ±0.15
pH_{144}	5.54^{B} ±0.09	5.41^{A} ±0.08	5.53 ±0.14
Colour lightness (L*)	54.96 ±3.05	55.65 ±2.78	55.31 ±2.91
Drip loss 48 h (%)	4.15^{A} ±1.87	6.07^{B} ±2.56	5.11 ±2.43
Drip loss 96 h (%)	7.37^{A} ±2.17	10.56^{B} ±3.04	8.96 ±3.07
Drip loss 144 h (%)	9.29^{A} ±2.47	13.19^{B} ±2.92	11.24 ±3.32
Weight lost in vacuum-packed meat 48 h (%)	2.10^{A} ±1.56	3.14^{B} ±1.57	2.65 ±1.65
Weight lost in vacuum-packed meat 96 h (%)	2.47^{A} ±2.05	7.30^{B} ±3.92	4.89 ±3.04
Weight lost in vacuum-packed meat 144 h (%)	4.82^{A} ±2.13	6.18^{B} ±2.20	5.50 ±2.70
Weight lost in MAP meat 48 h (%)	2.38^{A} ±2.10	5.92^{B} ±3.90	4.16 ±2.70
Weight lost in MAP meat 96 h (%)	3.62^{A} ±3.03	8.55^{B} ±8.06	6.09 ±5.28
Weight lost in MAP meat 144 h (%)	4.88^{A} ±3.87	8.94^{B} ±3.17	6.95 ±4.30
Technological yield of cured meat – TY (%)	93.17^{B} ±3.46	88.94^{A} ±4.54	91.05 ±4.54

The data shown in table are arithmetic means ±standard deviation (SD)
A, B – significant difference for traits at P≤0.01

tent in the group of (LxY) x D crosses, similar to the optimal value given by Wood and et al. [29], is indicative of favourable sensory properties highly valued by consumers (tenderness, juiciness and flavour). Higher intramuscular fat content in the muscle tissue of Duroc crossbreds as compared to crosses without this breed has also been reported by Antosik [3], Bertol et al. [4], Ĉandek-Potokar et al. [6], Łyczyński et al. [15] and Sieczkowska et al. [26].

The genetic group differentiated the course of glycolytic changes throughout the post--slaughter period (up to 144 h after slaughter), expressed as muscle acidity at 45 min and at 24, 48, 96 and 144 h post mortem. The LL muscle tissue of the (LxY) x D pigs had a lower rate of glycolytic transformation than that of the (LxY) x H group up to 45 min after slaughter, expressed as a higher pH_{45} (6.57 vs. 6.45). Analogously, a high rate of glycolytic transformations in the LL muscle tissue was also noted from 24 to 144 h after slaughter. The meat from the (LxY) x D fatteners had a higher pH_{24}, pH_{48}, pH_{96} and pH_{144} than that of the (LxY) x H crossbreds (by 0.15, 0.18, 0.24 and 0.13, respectively) – Table 2. It is worth noting the very low pH_{48} (5.34) in the LL muscle at 48 h post mortem, characteristic of acid meat (AM), in the group of (LxY) x H crosses (Tables 1 and 2). The low pH_{48} of the LL muscle in the group of Hampshire crossbreds is reflected in the high incidence of acid meat in this group – 73.33%. By comparison, the percentage of acid meat in the group of (LxY) x D pigs was only 10% (Fig. 1).

The low L_{48} in the LL muscle, high percentage of acid meat, and low yield of cured meat (TY) – about 89% (more than 4 pp lower) – recorded in the (LxY) x H genetic group as compared to the meat of pigs with a share of the Duroc breed (Tab. 2, Fig. 1) are characteristic of animals burdened with the RN^- gene (Napole yield), i.e. in the Hampshire breed and crosses with this breed [9, 13, 22, 23, 26, 31].

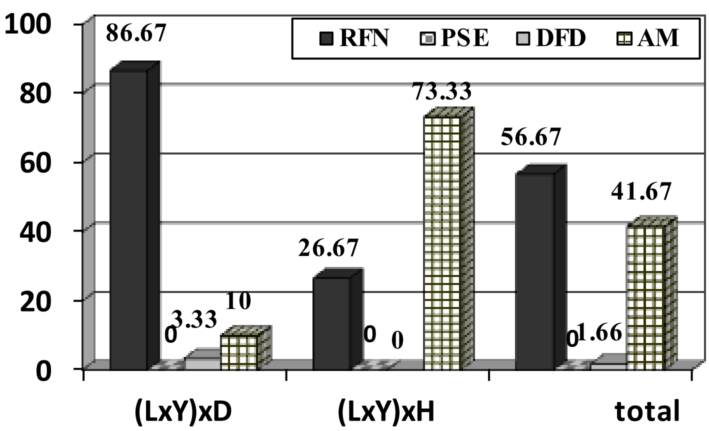

Fig. 1. Frequency of meat quality classes in the overall research material and in each genetic group (%)

The loss of meat juice from the LL muscle tissue during storage requires detailed analysis. Excessive dripping from meat reduces its potential for sale for cooking purposes. The use of the Duroc breed in cross-breeding of pigs had a positive effect in the present study, consisting in a significant reduction in drip loss from the LL muscle throughout the storage period. The meat of the (LxY) x D fatteners had a lower drip loss from the LL muscle during storage than that of the (LxY) x H crossbreds, by about 2 percentage points (4.15% vs. 6.07%) for DL_{48}, over 3 pp (7.37% vs. 10.56%) for DL_{96} and by 4 pp (9.29% vs. 13.19%) for DL_{144} (Table 2). In the group of (LxY) x D crosses, 53.3% of carcasses with dripping meat (DL_{48}> 4.0%) were diagnosed, as compared to 76.7% in the (LxY) x H group (Fig. 2).

Schäfer et al. [25], in an experiment conducted on Danish breeds of fattening pigs ((LxY) x D), reported a 55% incidence of dripping meat. Krzęcio [12], in a comparative analysis of nine genetic groups (including those used in the present study), found statistically significant differences in the drip loss at 48 h after slaughter between these groups. The lowest DL_{48} values, at a level of 5.29%, were noted in the meat of the (LxY) x D pigs. In a study by Josell et al. [8] on (LxY) x D fatteners, the drip loss at 48 h after slaughter was about 1.4 pp higher than the value obtained for the analogous genetic group in the present study.

The genetic group also differentiated the losses of vacuum packed meat (VAC) and meat portioned and packaged in a modified atmosphere (MAP) throughout the storage period. A much lower, statistically confirmed loss of meat packaged by the VAC and MAP methods at all measurement times, i.e. 48, 96 and 144 h after slaughter, was noted in the meat of the (LxY) x D crossbreds as compared to the (LxY) x H pigs (Table 2).

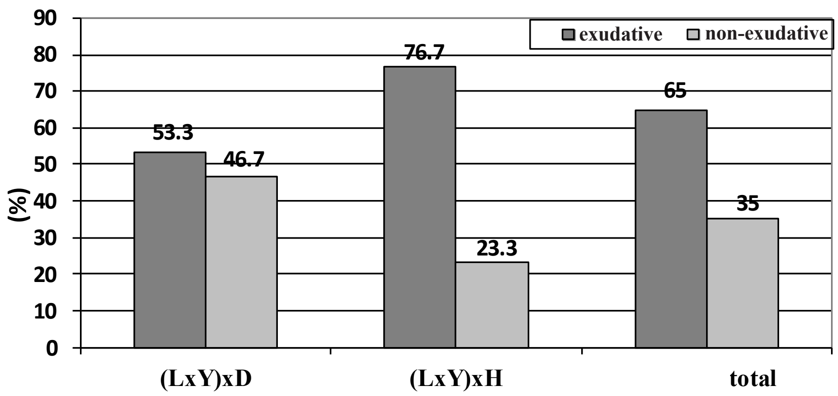

Fig. 2. Frequency of non-exudative and exudative meat in the overall research material and in each genetic group (%)

Vacuum packaging of meat (VAC) as well as packaging in a modified atmosphere after portioning (MAP) reduced the drip loss from the LL muscle at each measurement time, i.e. 48, 96 and 144 h post mortem, in both groups. It is worth noting the substantial reduction (by 7 pp) in the loss of meat juice during the entire storage period (up to 144 h after slaughter) from the vacuum packed (VAC) meat of (LxY) x H pigs. In contrast, the reduction in the loss of meat juice from meat packaged by the VAC method in the group of (LxY) x D pigs was only about 4.5 pp. In the case of portioned MAP meat, no significant differences were noted in the reduction in the loss of meat juice between experimental groups (LxY) x D and (LxY) x H throughout the storage period – 4.41 pp and 4.25 pp, respectively (Table 2).

The exceptionally unfavourable mean values obtained for meat quality traits of importance for cooking and processing confirm the need to eliminate the Hampshire breed on the paternal side from production of fattening pigs, due to the significant losses of fresh meat, unpackaged or packaged (MAP and VAC) during storage up to 144 h post mortem, as well as processed meat. Production of these pigs can be carried out in countries that prefer raw smoked products. The highly favourable values for characteristics important to the consumer (IMF and protein content, pH, weight loss of unpackaged and packaged meat throughout the storage period) and the processing industry (TY value) clearly support the use of the Duroc breed on the paternal side in the production of fattening pigs.

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