QUALITY AND TECHNOLOGICAL PROPERTIES OF MEAT FROM LANDRACE-YORKSHIRE × DUROC AND LANDRACE-YORKSHIRE × DUROC-PIETRAIN FATTENERS

Halina Sieczkowska, Maria Koćwin-Podsiadla, Elżbieta Krzęcio, Katarzyna Antosik, Andrzej Zybert

Chair of Pig Breeding and Meat Science, University of Podlasie, Siedlce, Poland

Key words: fatteners, crosbreds, hot carcass weight, RYR1 gene, meat quality

The present study was aimed at evaluating – for the domestic meat industry – the crosses of Danish pig breeds, originating from mating Landrace-Yorkshire (LY) sows with Duroc or Duroc-Pietrain (DP) boars, as regards their burdening with RYR1 gene, as well as meat quality and technological value (including hot carcass weight). The present study was aimed at evaluating – for the domestic meat industry – the crosses of Danish pig breeds, originating from mating Landrace-Yorkshire (LY) sows with Duroc or Duroc-Pietrain (DP) boars, as regards their burdening with RYR1 gene, as well as meat quality and technological value (including hot carcass weight). The studies were conducted on 64 porkers from two genetic groups: LY×D and LY×DP. Within each genetic group two weight classes were separated – 80 kg and 90 kg hot carcass weight. The model values for physicochemical properties and the technological value of meat obtained from LY×D fatteners, irrespective of the weight class (80 kg or 90 kg), as well as the 100% resistance of those animals to stress, fully justify their use for the commercial production of fatteners. In the national programme for commercial production the LY×DP crosses may also be used, though a preference should be made for slaughter at the higher hot carcass weight (90 kg) as a clear improvement was observed of the most important for the processing industry meat quality traits, expressed by the significantly lower drip loss during storage and higher technological yield (TY).

INTRODUCTION

The incompetent use of porkers in commercial crossing of both maternal (principally PL) and paternal lines (Pietrain, Hampshire) of high carcass meatiness may lead to a deterioration of the quality of meat products [Koćwin-Podsiadla, 1994; Różycki, 1998]. The national meat industry requires the raw material to meet high quality parameters with a simultaneous high share of meat in the carcass and prefers to slaughter fatteners at higher body weights. Despite the fact that the meat from lighter carcasses demonstrates a higher post-slaughter meatiness, it has a limited processing value [Grześkowiak, 1999; Zybert et al., 2001].

The breeds imported from Denmark, currently used in Poland for the improvement of slaughter pigs, are characterised both by a high muscle deposition and good quality of raw and processed meats, which is of special importance for the meat industry [Koćwin-Podsiadla et al., 2003, 2004b; Sieczkowska et al., 2007].

The parental animals of the fatteners tested were imported from Denmark (except Pietrain breed). The environmental and nutritional conditions were the same for all animals (Cargill complete concentrates according to age) throughout the rearing period and so were the slaughter and post-slaughter procedures. The fatteners were slaughtered during the autumn season (September-October), 2-4 h after transport (300 km), using an electric stunner (INARCO Dutch line) and bled lying down, in accordance with the procedure accepted at the Meat Plant SOKOŁÓW S.A., Sokolów Podlaski, Poland.

The analysed fatteners were characterised by a mean lean meat content (estimated at the Polish Pig Progeny Testing Station with the dissection method) at a level of 57.01±3.10%.

The material estimated was analysed for burdening with RYR1 gene according to the PCR/RFLP method [Kurył & Korwin-Kossakowska, 1993].

The evaluation of the quality of meat was performed after slaughter on the Longissimus lumborum (LL), on the basis of the following parameters: glycolytic potential (GP) and its components, i.e. content of glycogen and lactic acid, degree of muscle acidity (pH), electrical conductivity (EC), rate of ATP
decomposition expressed by $R_e = \text{IMP}/\text{ATP}$, meat lightness ($L^*$), water holding capacity determined with the filter paper method (WHC), drip loss (DL), technological yield in curing and cooking processing (72°C), expressed by a TY indicator.

The glycolytic potential and its components were determined on samples of the LL muscle taken 45 min post mortem. The GP was calculated according to the formula elaborated by Monin & Sellier [1985], the content of glycogen according to the method by Dalrymple & Hamm [1973] and that of lactic acid according to Bergmeyer [1974]. The pH measurement was performed directly on the LL muscle 35 min and 24 h post mortem using a pistol pH-meter MASTER (Draminski, Olsztyn, Poland) calibrated with temperature compensation.

Moreover, 45 min after slaughter the pH was determined in a water homogenate of the muscle tissue, using a CP-311 pH-meter (Elmetron, Poland) with a glass-combined electrode type OSH-10-OO. The EC was measured using an LF-Star conductometer (Ingenieurbüro Matthäus, Noblitz, Germany) 2 h after slaughter. The lightness of the muscle tissue ($L^*$) was determined using a Minolta apparatus (model CR 310, Minolta, Osaka, Japan) 24 h after slaughter. The value of an R indicator, determined 45 min post mortem according to the method by Honikel & Fischer [1979]. The WHC was determined 24 h post mortem according to the method by Grau & Hamm [1952] as modified by Pohja & Ninivaara [1957]. In turn, 48 h post mortem determinations were made for the drip loss according to Prange et al. [1977] and the meat yield in the curing and thermal processing (72°C), expressed by TY (technological yield) indicator, according to Naveau et al. [1985] as modified by Koćwin-Podziadla et al. [1998].

The samples of LL muscle were taken 24 h after slaughter. Meat cubes 1 x 1 x 1 cm were immersed in a solution containing 12% of NaCl, 0.07% of NaNO$_3$, and 0.06% of glucose. After 24 h of curing at 4°C, the samples were thermally processed in a water bath (to an internal temperature of 72°C).

Moreover, the samples obtained from the LL muscles were analysed for proximate composition: water and dry matter according to the PN-ISO 1442:2000 standard, total protein content according to the method by Kjeldahl [PN-75/A04018] and intramuscular fat according to the method by Soxhlet [PN-ISO 1444:2000].

The material analysed was also tested for the frequency of the $R_{YRI}^T$ gene using the PCR/RFLP method [Kurtył & Korwin-Kossakowska, 1993].

On the basis of the extreme values obtained for pH$_{a5}$, pH$_{a24}$ and R$_e$, four meat quality classes were separated post mortem: RFN – reddish-pink, firm, non exudative, PSE – pale, soft, exudative, AM – acid meat, and DFD – dark, firm, dry [Koćwin-Podziadla, 1993; Koćwin-Podziadla et al., 1998, 2004a].

The results obtained were elaborated statistically using a two-factor analysis of variance in an orthogonal arrangement demonstrated a highly significant or significant (at $p \leq 0.01$ and $p \leq 0.05$) effect of the genetic group on the majority of the meat quality parameters analysed (except for the value of the glycolytic potential, total protein content, meat lightness, WHC and technological yield – TY), (Table 1).

The effect of the hot carcass weight class was confirmed only for the content of intramuscular fat (at $p \leq 0.05$). More beneficial values of the above-mentioned parameter were affirmed in the heavier fatteners group (Table 1).

An interaction was observed between the two factors examined (genetic group × hot carcass weight class) for the value of the glycolytic potential (at $p \leq 0.05$) and the acidity level of the LL muscle 24 h post mortem (at $p \leq 0.01$), (Table 1, Figures 1 and 2).

The three-breed LY×D crosses (irrespectively of the hot carcass weight class) were characterised by a higher content of dry matter and intramuscular fat (25.38% and 2.08%, respectively) as compared to the LY×DP fatteners (22.76% and 1.68%, respectively), (Table 1). Increasing the carcass weight to 10 kg (from 80 to 90 kg) in the group of LY×D crossbreds resulted in a statistically significant (by 0.66%) increase in the content of intramuscular fat (from 1.59 for the 80 kg to 2.25 for 90 kg), (Table 2).

The content of intramuscular fat similar to that reported by Wood et al. [1994] as optimal, was obtained only for the LY×D fatteners, fattened till the heavier carcass weight and indicating favourable sensory properties of meat, such as tenderness, juiciness and taste, so highly valued by consumers.

Candek-Potokar et al. [1998], Koćwin-Podziadla et al. [2004b] and Krzęcio et al. [2004] examined populations of LY×D crossbreds, obtained an intramuscular fat content similar to that recorded in the present work for an analogous genetic group.

Fatteners obtained by four breeds LY×DP, compared with the three-breed crosses LY×D, were (irrespectively of the class of hot carcass weight) characterised by a quicker glycolytic metabolism 45 min post mortem, expressed by a lower con-
The table presents value F content of glycogen (41.10 µmol/g vs. 39.57 µmol/g) and for R1 of the group of LY×D fatteners for pH tor (0.98) (Table 1). The values obtained in the LL muscle compared with the LY×DP crosses (Table 1). Moreover, in the meat of those animals, a more intensive energy metabolism was observed, expressed by the R1 indicator (0.98) (Table 1). The values obtained in the LL muscle of the group of LY×D fatteners for pH24 and pH45 (6.48 and 6.18, respectively) and for R1, i.e. the indicator of energy metabolism (0.85), are typical for normal meat (Table 1). Those crosses were additionally characterised by a lower electric conductivity measured 2 h post mortem (by 0.53 mS/cm) compared to the LY×DP crosses (Table 1). The comparatively rapid degree of muscle tissue acidity and intensive breakdown of ATP (expressed by the R1 indicator) in LY×DP crossbreds during the first 45 min after slaughter was reflected by the frequency of PSE meat, which in this genetic group accounted for 19% (Table 3). The presence of meat with the PSE syndrome only in the group of crosses having a 25% share of P. indica-

tent of lactic acid (50.17 µmol/g vs. 47.44 µmol/g) determined 45 min post mortem, and in a consequence by a lower value of pH24 and pH45 in the LL muscle (6.48 and 6.18, respectively), (Table 1). Moreover, in the meat of those animals, compared with the LY×D crossbreds, a more intensive energy metabolism was observed, expressed by the R1 indicator (0.98) (Table 1). The values obtained in the LL muscle of the group of LY×D fatteners for pH24 and pH45 (6.62 and 6.60, respectively) and for R1, i.e. the indicator of energy metabolism (0.85), are typical for normal meat (Table 1). Those crosses were additionally characterised by a lower electric conductivity measured 2 h post mortem (by 0.53 mS/cm) compared to the LY×DP crosses (Table 1). The comparatively rapid degree of muscle tissue acidity and intensive breakdown of ATP (expressed by the R1 indicator) in LY×DP crossbreds during the first 45 min after slaughter was reflected by the frequency of PSE meat, which in this genetic group accounted for 19% (Table 3). The presence of meat with the PSE syndrome only in the group of crosses having a 25% share of P. indica-

![FIGURE 1](image1.png)

**FIGURE 1.** Interactive effect of genetic group and the class of hot carcass weight on the glycolytic potential. Explanations: a, b – difference significant at p≤0.05.

![FIGURE 2](image2.png)

**FIGURE 2.** Interactive effect of genetic group and the class of hot carcass weight on pH24 post mortem of the LL muscle. Explanations: A, B, C – difference significant at p≤0.01.
TABLE 2. Meat quality traits as affected by increasing hot carcass weight from 80.0 kg to 90.0 kg in respective genetic groups.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Genetic group</th>
<th>Hot carcass weight</th>
<th>Femp</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>Intramuscular fat content (%)</td>
<td>LY×D</td>
<td>1.59±0.47</td>
<td>2.29±0.88</td>
<td>2.08*</td>
</tr>
<tr>
<td></td>
<td>LY×DP</td>
<td>1.39±0.17</td>
<td>1.50±0.33</td>
<td>1.43 NS</td>
</tr>
<tr>
<td>Drip loss 48 h (%)</td>
<td>LY×D</td>
<td>4.62±1.52</td>
<td>5.69±2.62</td>
<td>1.99 NS</td>
</tr>
<tr>
<td></td>
<td>LY×DP</td>
<td>9.14±2.97</td>
<td>6.31±3.03</td>
<td>7.04**</td>
</tr>
<tr>
<td>WHC (cm³)</td>
<td>LY×D</td>
<td>5.68±1.56</td>
<td>5.14±0.65</td>
<td>1.61 NS</td>
</tr>
<tr>
<td></td>
<td>LY×DP</td>
<td>6.10±0.67</td>
<td>5.38±0.90</td>
<td>6.03 *</td>
</tr>
<tr>
<td>TY (%)</td>
<td>LY×D</td>
<td>105.20±3.82</td>
<td>103.36±4.02</td>
<td>1.76 NS</td>
</tr>
<tr>
<td></td>
<td>LY×DP</td>
<td>102.13±3.50</td>
<td>106.12±4.20</td>
<td>8.53*</td>
</tr>
</tbody>
</table>

Explanations: The table presents value F<sub>emp</sub> and level of significance "*" p≤0.01; "**" p≤0.05; NS – differences insignificant. The data shown in the table are arithmetic means ± standard deviation; A, B – significant difference for the analysed traits at p≤0.01; a, b – significant difference for the analysed traits at p≤0.05; WHC – water holding capacity, TY – Technological Yield.

TABLE 3. Frequency of faulty meat.

| Class of meat quality | Frequency of faulty meat (%) | | |
|-----------------------|------------------------------|---|
|                       | LY×D                         | LY×DP                       |
| RFN                   | 100                          | 81.25                       |
| PSE                   | 0                            | 18.75                       |
| AM                    | 0                            | 0                           |
| DFD                   | 0                            | 0                           |

etrain blood on the paternal side is related to the presence in their genotype (in a heterozygosis form) of the stress susceptibility gene RYR1. Worthy of notice is that in the group of LY×D crossbreds, which were free of the RYR1 gene, there were no carcasses with PSE type meat (Table 3).

As regards the degree of acidity of the LL muscle 24 h after slaughter, the results obtained for LY×D and LY×DP crosses, irrespectively of the carcass weight warm, were similar and typical for normal meat (5.67 and 5.64, respectively), (Table 1). Josell et al. [2003], examining LY×D fatteners observed a lower rate and degree of acidity, expressed by a lower pH<sub>i</sub> and pH<sub>4h</sub> of the LL muscle as compared to the results obtained in the present work on an analogous genetic group.

In turn, Candek-Potokar et al. [2002], also examining a group of LY×D crossbreds, reported a more rapid decrease of pH during the first 45 min post mortem than both cited earlier and observed in the present studies. However, the acidity of the muscle tissue 24 h after slaughter was similar to that reported herein.

Krzęcio et al. [2004], in an experiment conducted on six genetic groups, including LY×D and LY×DP, reported analogous tendencies and similar results to those observed in the present study as regards the acidity of the LL muscle 45 min and 24 h post mortem, electric conductivity 2 h after slaughter and electric metabolism expressed by the R<sub>i</sub> indicator. In the LY×DP fattener the frequency of PSE meat calculated by the authors cited accounted for 12.5% and was lower than that observed in the present work by 6.5%.

The drippage loss from the muscle tissue observed during storage must be analysed in detail as an excessive drip loss limits the possibility of selling the product as culinary meat.

The use of the Duroc boars for commercial crossbreeding (LY×D) had, in the present studies, a positive effect on the considerable reduction of natural drip from the LL muscle 48 h after slaughter. Fatteners LY×D were (irrespective of the hot carcass weight) characterised by a lower drip loss from the LL muscle during storage (from 24 to 48 h after slaughter), i.e. on average by 2.6% in relation fatteners LY×DP (Table 1). Drip loss noted 48 h post mortem in the group of LY×D porkers at a level of 5.16% (Table 1) fits within extreme values stipulated by Bertram et al. [2000] for normal – non exudative meat.

Despite the differences observed between the genetic groups analysed in the volume of drip loss occurring during storage, there were no statistically significant differences recorded in the technological value expressed by the TY indicator. The values obtained for this indicator turned out to be high, i.e. 104.28% for LY×D and 104.12% for LY×DP (Table 1).

In studies conducted by Cheah et al. [1998] and Josell et al. [2003] on LY×D crossbreds, the drip loss measured 48 h post mortem was by 1% lower than that obtained in the present investigations on an analogous group of pigs.

Increasing the hot carcass weight by 10 kg (from 80 kg to 90 kg) in LY×D crossbreds did not result in any statistically significant differences recorded in the technological value expressed by the TY indicator. The values obtained for this indicator turned out to be high, i.e. 104.28% for LY×D and 104.12% for LY×DP (Table 1).

These tendencies noted in the LY×DP fatteners were confirmed by the lowest value of the glycolytic potential recorded 45 min post mortem and, to a smaller degree, by the lower acidity of the LL muscle 24 h post mortem (Figures 1 and 2). Moreover, in the LY×DP genetic group the increase of carcass weight by 10 kg resulted in a statistically confirmed increase of pH recorded 24 h post mortem (from 5.58 to 5.69), (Figure 2).
CONCLUSIONS

Summarizing, the model values obtained for the physico-chemical properties and the technological value of meat from LY×D fatteners having a 50% share of the Duroc breed on the paternal side ( irrespectively of the HCW class of 80 kg or 90 kg), together with the 100% resistance of these animals to stress, fully justify the use of this type of crossing for the commercial production of fatteners. In the domestic programme for commercial production there may also be used crossbreds with a 25% share of the resistant to stress Pietrain breed on the paternal side – LY×DP. In the case of the latter cross, one should prefer slaughter at a higher hot carcass weight (90 kg), as at that weight one may observe a clear improvement of meat quality properties important for the meat industry and expressed by a significantly lower drip loss during storage and higher technological value of meat (TY). This would make it possible to obtain from those animals carcases comparable to carcases of three-breed crosses LY×D, both as regards lean meat content (57%) and meat quality.

REFERENCES


Received October 2008. Revision received June and accepted August 2009.