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Comparative assessment of the quality of meat and lard products of three-way crossbred pigs

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ABSTRACT

A comparative assessment analysis of meat and back fat quality of crossbred boars of Duroc (D) and Pietrain (P) breeds, mated with sows obtained from direct and back crossing is presented in the article: the combination of Large White (LW) gilts and Landrace (L) boars and the combination of Landrace (L) gilts and Large White (LW) breed boars. No significant differences were found in the meat active acidity of slaughtered animals in different groups. This indicator was within the 5.69-5.79 unit range and corresponded to the regulatory values. The difference was noted between various groups in the tenderness index, which is connected with using boars of different breeds as the final paternal form. Thus, when using D boars, tenderness values varied from 7.92 to 9.75 sec., while when using P boars, the values of this indicator were within 11.40-11.71 sec. Moisture-retention power indicators were within the normal range for all groups of animals. The animals with ½ D genotype and young stock obtained from the combination of (LW×L) sows with P boars were characterized by insignificant differences in this indicator. Instead, the combination (L×LW)×P was characterized by the lowest moisture-retention power values, yielding to the other groups. In comparison with the (L×LW)×D group, this difference was 5.27% and had a significant value ($p < 0.05$). The combination of (L×LW)×P was characterized by the highest values of cooking loss, surpassing those of the other groups. When compared with the (L×LW)×D group, this difference had a significant value of 3.02% ($p < 0.05$). The total moisture content in the meat was 73.55 - 74.97%. Regarding ash content, meat samples from pigs with the ½ D genotype, compared with young stock of the ½ P genotype, had lower values of this indicator. The highest values of protein content were in meat samples obtained from young pigs with ½ D genotype. Fat content in the meat of the experimental groups was within 2.14-3.22%, corresponding to physiological standards. According to the results of the tasting analysis, the samples of the longissimus dorsi muscle, back fat, and broth received high appraisal. However, significant differences between the groups were not revealed.

Keywords: pork, meat quality, longissimus dorsi muscle, back fat, crossbred

INTRODUCTION

Livestock farming is a traditional industry in Ukraine that can provide meat products to our country and export them **[1]**, and **[2]**. Currently, pork remains one of the most consumed types of meat **[3]**. Following the "One Health" **[4]** concept, its quality determines the quality of products that ensure the optimal level of the population's health. Accordingly, it depends on consumer demand and competitiveness in the domestic and international markets. Taking it into account, considerable attention should be paid to the epizootic status of productive stock, from which the quality of livestock products depends **[5]**, and **[6]**. Correspondingly, only the complex of

technological, veterinary, and sanitary measures can ensure the obtaining of high-quality and safe animal origin products **[7]**, **[8]**, and **[9]**.

Considering the considerable demand for this type of meat and its products, it can also be maintained that it is formed owing to its organoleptic and physical-chemical properties. Therefore, in modern conditions, when research focuses on increasing prolificacy, meat content, and rapid growth in animals, it must also be directed at simultaneously preserving meat taste qualities **[10]** and **[11]**.

The studies by many scientists have proven that pork quality is determined by certain characteristics, such as organoleptic quality, nutritional value, the content of intramuscular fat, and various aromatic substances **[12]** and **[13]**. These characteristics are formed under the influence of a complex interrelationship of many factors, namely: genetic, age, sex, feeding, keeping conditions, transportation, slaughter technology, and post-slaughter processing of carcasses **[14]**, **[15]**, **[16]**, and **[17]**.

Analyzing product quality, we primarily rely on organoleptic assessment, which is formed by the sense organs and consists of appearance (color, marbling), texture (tenderness, juiciness), aroma, and taste **[18]**. Given that meat is the main component of our diet, the assessment of nutritional value, which is determined by the content of protein, fat, essential amino acids, polyunsaturated fatty acids, vitamins, micro- and macro-elements, is an extremely important measure **[19]**, and **[20]**.

Considering the biological peculiarity of pigs – fat accumulation, and correspondingly, the assessment according to this component is mandatory since its content forms certain technological (consistency, moisture retention power) and nutritional (taste, juiciness) qualities of pork **[21]**, **[22]**, and **[23]**. However, excessive fat content in pork can increase the risk of reduced consumer demand **[24]**. Fat accumulation is mainly influenced by the diet and breed of pigs **[25]**, and **[26]**.

Targeted selection for increased productivity and lean meat indicators in pigs has led to a deterioration in meat quality over the recent decades **[27]**. It is now known that with increasing daily gains and muscular cell area in pigs, we get a higher output of lean meat. However, a high percentage of lean meat can worsen meat quality, as a decrease in marbling can decrease pH, the meat's color becomes lighter, and moisture loss increases **[28]**, and **[29]**.

At present, there are a significant number of pig breeds. Still, industrial pork production requires animals that can satisfy the requirements of the producer and, of course, the consumer; accordingly, a limited number of breeds are currently used, which, by crossing with each other, can manifest the effect of heterosis **[30]**. Among the breeds of commercial importance that have become the most widespread in Ukraine and are used in the hybridization system, the following breeds should be distinguished: Large White, Landrace, Duroc, Pietrain **[31]**. However, it should be noted that there is a certain difference in meat quality between these breeds **[32]**, **[33]** and their mongrels obtained during industrial crossing **[34]**, **[35]**, and **[36]**. Thus, further research in this direction remains relevant, particularly in light of economic efficiency and consumer demand.

Scientific Hypothesis

The scientific hypothesis is based on the fact that the data from physical-chemical analysis and organoleptic assessment of meat and back fat quality of pigs obtained from various outcrossing will allow us to assess the variability of these qualities between different genotypes and, accordingly, the prospects for using certain combinations to produce high-quality meat products. Considering that the content of intramuscular fat and moisture-retention power have the greatest impact on the quality of meat products, these data are of the most significant scientific interest.

Objectives

Primary objectives: This study compared the physical-chemical analysis and organoleptic evaluation of the meat and back fat quality of three-way crossbred pigs.

MATERIAL AND METHODOLOGY

Samples

Samples description:

20 young pigs were used in the study, namely 5 from different interbreed crosses. The crossbreeds of Duroc (D) and Pietrain (P) breed boars mated with sows obtained from direct and back crossing were compared: the combination of Large White (LW) sows and Landrace (L) boars, and the combination of Landrace (L) gilts and Large White (LW) boars. Accordingly, 4 groups were formed: (LW×L)×D, (L×LW)×D, (LW×L)×P, (L×LW)×P.

Each experimental group selected 5 heads with a live weight of 100±5 kg for control slaughter **[37]**. Animal selection, labeling, transportation to the place of slaughter and other technological operations were conducted according to the National Standard of Ukraine (DSTU) 4718:2007 **[38]**. Slaughter guided by the requirements of

DSTU 7158:2010 **[39]** was carried out at the meat processing factory of "Miasny Maister" LLC, (Zhmerynka city, Vinnytsia region, Ukraine). The *longissimus dorsi* muscle and back fat were sampled following DSTU 7992:2015 **[40]**. Our research was conducted in accordance with "Methodology and organization of scientific research in animal husbandry", which states that to assess meat quality using the control slaughter method, a small sample of 3-5 heads from a group is sufficient for statistical data processing **[37]**.

Samples collection: A sampling of *longissimus dorsi* muscle and back fat was collected and temporarily stored at a temperature of +4±2°C.

Samples preparation: The *longissimus dorsi* muscle and back fat samples were unpacked and divided into several parts for the physical-chemical analysis and organoleptic assessment.

Number of samples analysed: 20 samples *longissimus dorsi* muscle, 20 samples back fat.

Chemicals

All chemicals were purchased from reputable brands on the market and met the highest analytical standards:
Sulfuric acid ("SUMYKHIMPROM" Private Joint-Stock Company (PJSC), Ukraine);
Petroleum ether (Thermo Fisher Scientific, USA);
Hydrochloric acid "DNIPROAZOT" JSC, Ukraine);
Copper sulfate pentahydrate (LLC "Kostiantynivka plant of metallurgical equipment", Ukraine);
Potassium sulfate ("Kostiantynivka state chemical plant", Ukraine);
Natrii hydroxidum ("Alchim" LLC, Ukraine);
Boracic acid (PJSC Pharmaceutical factory "Viola", Ukraine);
Methyl red (PJSC "Shostka plant of chemical reagents", Ukraine);
Methyl blue (PJSC "Shostka plant of chemical reagents", Ukraine);
Ethanol (PJSC Pharmaceutical factory "Viola", Ukraine).

Animals, Plants and Biological Materials

The meat taken from experimental pigs' longissimus dorsi muscle and back fat were used as a biological material for the studies. The pigs were kept in "Weda Podillia" LLC production conditions, (Ternopil region, Pidvolochyskyi district, Podillia village, Ukraine). It is a modern pig farm having 245 sows with the complete production cycle. Automated feeding systems ensure animal feeding on the farm at the expense of full-ration combined feeds of one's own production. Animals are kept in individual or group stalls following technological standards, on slotted floor.

Instruments

pH-meter of pH-150M model (RUE "Gomel plant of measuring instruments", Republic of Belarus);
Laboratory cabinet dryer SNOL -24/200 ("SNOL Ukraine" LLC, Ukraine);
Muffle electric furnace SNOL 3/1100 LHM ("SNOL Ukraine" LLC, Ukraine);
Electronic laboratory scales WPS 360/C/1 ("Radwag", Poland);
Digital thermometer AMA-digit ad 14th ("Amarell", Germany);
Device Warner-Bratzler modification of V. Ya. Maksakov (Ukraine);
Water bath BV-4 ("Vetinstrument" LLC, Ukraine);
Kjeldahl flask ("Sklopryladd" PJSC, Ukraine);
Soxhlet apparatus ("Sklopryladd" PJSC, Ukraine).

Laboratory Methods

The study was conducted in the Laboratory of Animal Nutrition, Physiology and Health of the Institute of Breeding and Agro-Industrial Production of the National Academy of Agrarian Sciences of Ukraine according to methodological recommendations **[41]**, and **[42]** and regulatory documents – the National Standard of Ukraine (DSTU).

The material for the research was pig back fat and meat. The total fat content in pork was determined according to DSTU ISO 1443:2005 **[43]**; the total ash content was determined according to DSTU ISO 936:2008 **[44]**; moisture content was determined according to DSTU ISO 1442:2005 **[45]**; and active acidity (pH) 48 hours after slaughter was determined according to DSTU ISO 2917-2001 **[46]**. The mass fraction of protein was determined by the nitrogen content corrected for the appropriate coefficient, according to the Kjeldahl method (formula 1), which was determined according to DSTU ISO 937:2005 **[47]**:

$$P = 6.25 \times N \quad (1)$$

Where: P is the mass fraction of total protein, %;
*6.25*is the correction coefficient;
N is the mass fraction of total nitrogen, %.

The moisture-retention power was determined by the press method of R. Grau and R. Hamm **[48]**; meat tenderness was determined by the method of D. L. Levantin; the difference in the sample weight was calculated cooking loss before and after the treatment with dry heat in a water bath for 50 minutes. In freshly melted back fat, the following indicators were determined: hygroscopic moisture by drying at a temperature of 105 °C; the melting point was measured in a direct capillary open on both sides with a diameter of 1.5 mm, using a digital thermometer.

A tasting commission of six experts conducted an organoleptic evaluation of back fat, boiled meat, and broth using a five-point scale specially developed in accordance with DSTU 4823.2:2007 **[49]**.

Description of the Experiment

Study flow: In the experiment's first phase, before slaughter, the animals were kept without feed for 24 hours with free access to water. The animals were transported by specialized transport. The pigs were moved to a pre-slaughter premise upon arrival at the meat processing factory. Before slaughter, all animals were stunned with an electric current. Then, they were bled, scalded in tanks, and singed with gas burners to remove bristles; internal organs were removed, evisceration was conducted, the carcasses were sawn and trimmed. After that, a veterinary expert examined each carcass and determined its weight.

After 24 hours of holding pigs' half-carcasses in a refrigerating chamber at a temperature of 2 – 4 °C, they were sent for bone removal, during which samples were taken. From each left half-carcass, one sample of meat was taken from the longissimus dorsi muscle and back fat in the area at 9 – 12 thoracic vertebrae level.

The samples were freed from connective tissue, placed in a Zip-Lock bag and labeled. They were transported to the laboratory in a refrigerated bag at a temperature of 4±2 ºC.

Design of the experiment: The experiment involved second-order hybrids obtained through industrial crossing from different combinations of four breeds, divided into four groups. The first stage of the research aimed to study the growth intensity of the evaluated young stock, feed consumption, and other fattening indicators. When the animals reached a live weight of 100±5 kg, 5 pigs were selected from each group for control slaughter, slaughter and meat indicators assessment, and analysis of meat products' quality. The obtained laboratory research data were statistically processed and analyzed.

Quality Assurance

Number of samples analyzed: A total of 20 samples of the longissimus dorsi muscle and 20 samples of back fat were examined. Three replicates were performed for each sample to measure the physico-chemical parameters, and six replicates were performed to measure meat tenderness.

Number of repeated analyses: The experiments were repeated in 4 groups of animals obtained from different interbreed crosses.

Number of experiment replication: The study was conducted one time.

Reference materials: The pH meter was calibrated using standard titers. Buffer solutions with pH values such as pH 4.00 (KCl), pH 7.00 (phosphate buffer), pH 10.00 (NaOH) were used as standard samples.

An additional control experiment is conducted each time new batches of reagents or freshly prepared solutions are used. Also, from time to time, a control experiment is carried out for reagents and solutions that have already been used for a certain time.

Scale calibration is carried out using reference weights to check accuracy. Control of several measurements should ensure reliable results.

Calibration: To ensure the accuracy and reliability of measurements in this study, laboratory equipment and instruments were calibrated following established standards and manufacturers' recommendations. Reference materials following international standards were used to confirm the accuracy of measurements, and secondary reference materials were used for additional data verification. The pH meter was calibrated immediately before analysis using standard titers.

Laboratory accreditation: The experiments were performed in a laboratory accredited according to the international standard ISO 17025.

Data Access

The data supporting the findings of this study are not publicly available.

Statistical Analysis

Statistical processing of the results was conducted using the methods of variation statistics of Statistica 10 (10.0.1011) (StatSoft Inc., USA). The data were analyzed for outliers using the Grubbs's test (extreme studentized deviate method) and normality of residuals using the Shapiro-Wilk normality test. The results are presented as mean ± standard error ($x \pm SE$). The results were considered statistically significant at a 95.0% reliability level ($p < 0.05$) for all data, as calculated using the Tukey test.

RESULTS AND DISCUSSION

The analysis of the research results did not reveal considerable differences in active acidity in the meat of slaughtered animals from different groups (Table 1). This indicator was within 5.69-5.79 units and corresponds to the standard (NOR) range from 5.3 to 6.0 units **[50]**. At the same time, the use of sows from the direct combination of (LW×L) with different boars provided the most contrasting values, namely, the group that was crossed with P boars had higher values by 0.1 unit ($p<0.05$) as compared with the animals obtained from the combination with D boars. When using sows from the back crossing combination of (L×LW), both with D and P breeds of boars, the indicators of active acidity were at the same level, the difference made 0.01 unit. Somewhat similar values of active acidity were obtained by a group of scientists comparing 4 groups of crossbred pigs, but according to their results, meat samples of the pig combination (Landrace×Yorkshire)×Duroc had significantly higher ($p<0.01$) pH values – by 0.27 units in comparison with (Deutsche Landschwein×Deutsche Edelschwein)×Pietrain **[51]**. Other researchers have shown significantly higher values of this indicator in meat samples of D purebred animals than in P **[52]**.

Table 1 The results of physical-chemical analysis of meat (longissimus dorsi muscle of pigs).

Combination	pH (48 hrs.)	Tenderness, sec.	Moisture-retention power, %	Cooking loss, %
(LW×L)×D	5.69±0.05	7.92±0.33	56.39±1.91	20.34±0.81
(L×LW)×D	5.74±0.01	9.75±0.58	58.46±1.23	18.62±1.07
(LW×L)×P	5.79±0.01 *	11.71±0.82 **	57.40±0.67	20.73±0.49
(L×LW)×P	5.75±0.01	11.40±0.72 **	53.19±1.05 [1]*	21.64±0.31 [1]*

Note: *) $p<0.05$ was calculated for the combination of (LW×L)×D; **) $p<0.01$ was calculated for the combination of (LW×L)×D; [1]*) $p<0.05$ was calculated for the combination of (L×LW)×D.

In terms of tenderness, an important quality characteristic crucial for consumers' perception and satisfaction with the final product **[53]**, the difference was noted between different groups, which is connected with the use of boars of various breeds as the final paternal form. Thus, when using D boars, tenderness values varied from 7.92 to 9.75 sec., while when using P boars, the values of this indicator were within 11.40-11.71 sec. This proves that lower values of this indicator distinguished meat samples obtained from young pigs with the ½ D genotype, and the combination of (LW×L)×D differed by 3.48-3.79 sec. ($p<0.01$) from animals obtained from crossing with P boars. The results of studies by other scientists **[54]**, and **[55]**, at comparing purebred pigs of D and P breeds, prove that the meat of D breed animals is more tender and differs in texture, correspondingly, it can be stated that the results of our studies were largely affected by the paternal component. This may be due to certain polymorphisms in the genes encoding CAPN and CAST, which affect meat tenderness during maturation through the formation of proteolytic enzymes involved in protein breakdown (CAPN) whose inhibitors are calcium ions (CAST), as well as meat texture **[56]**.

The moisture retention power (MRP) of meat and meat products determines visual acceptability, weight loss, readiness, and taste properties during product consumption **[57]**. The results of this indicator's assessment are similar to those obtained by other researchers **[58]**, and **[59]**, which indicates that these values are within the normal range for all groups of animals. At the same time, animals with the ½ D genotype and young stock obtained from the combination of (LW×L) sows with P boars were characterized by insignificant differences in MRP values. On the other hand, the combination of (L×LW)×P was described by the lowest MRP values, yielding to the different groups, and as compared with the (L×LW)×D group this difference made 5.27% and had a significant value ($p<0.05$). It should be noted that meat obtained from different genotypes can retain moisture differently, in our opinion and that of other scientists **[60]**, one of the main factors influencing this indicator is the genes of quantitative traits. It has been proven that mutations in the ryanodine receptor 1 (RYR1) gene can affect the formation of pale, soft, and exudative (PSE) meat **[61]**. But currently, according to the leading pig breeding centers, this RYR1 mutation gene has been excluded in commercial breeds. However, Chinese researchers **[62]** proved that the differential expression of PLVAB, ADIPOQ, LEP, MYH4, MYH7, MYL3, MYL6B, FOS, ATF3, and HSPA6 may induce PSE formation in the longissimus lumborum, and HSPA6 may induce PSE formation in

the longissimus lumborum, and PPP1R3G and MSS51 may be key genes regulating pork quality in the semimembranosus. To clarify this question, it is also desirable to conduct genetic analysis to identify undesirable genes.

The analysis of cooking loss revealed that more losses were also obtained from pigs with the ½ P genotype. The combination of (L×LW)×P were characterized by the highest values of this indicator, yielding to the rest of the groups, and when compared with the (L×LW)×D group, this difference had a significant value of 3.02% ($p<0.05$). Some scientists draw attention to the slightly lower values of losses during cooking of meat samples of D purebred animals in comparison with animals of P breed **[55]**. However, opposite values were obtained by the results of other researchers **[54]**, and **[63]**.

Most of the indicators of meat chemical analysis (Table 2) also showed significant differences between the different animal groups.

Table2 The results of meat chemical analysis (longissimus dorsi muscle of pigs).

Combination	Total moisture, %	Dry matter, %	Ash, %	Protein, %	Fat, %
(LW×L)×D	73.95±0.28	26.05±0.28	1.29±0.01	22.61±0.19	2.14±0.45
(L×LW)×D	73.55±0.24	26.45±0.24	1.24±0.03	23.31±0.83	3.22±0.25
(LW×L)×P	74.38±0.27	25.62±0.27	1.62±0.07 * [1]**	21.09±0.04 [1]**	2.91±0.31
(L×LW)×P	74.97±0.28 * [1]**	25.03±0.28 * [1]**	1.58±0.12 * [1]**	20.71±0.38 * [1]**	2.41±0.35

Note: *) $p<0.05$ was calculated for the combination of (LW×L)×D; [1]**) $p<0.01$ was calculated for the combination of (L×LW)×D.

According to the physiological norm **[64]**, the muscle contains approximately 75% of water, 20% of protein, and 5% of lipids or fat. The analysis of the obtained data proves that the indicators of the experimental groups were within the normal range. For example, the total moisture content in the meat made 73.55-74.97%, but it should be mentioned that pigs with the ½ P genotype had somewhat higher moisture content, and in terms of dry matter content, these indicators, on the contrary, were lower. In addition, the combination of (L×LW)×P had a significant value difference in indicators, so concerning the (LW×L)×D group the difference made 1.02% ($p<0.05$), and to the (L×LW)×D group – 1.42% ($p<0.01$). Similar results were obtained by some researchers, namely, P purebred pigs and hybrids of this breed had somewhat higher moisture content in meat **[65]**, **[66]**, and **[67]**.

As far as ash content is concerned, meat samples from pigs with the ½ D genotype, as compared with ½ P young pigs, had lower values of this indicator, namely by 0.29-0.33% ($p<0.05$) obtained from (LW×L) sows, and by 0.29-0.34% ($p<0.01$) from (L×LW) sows.

Protein mass fraction is one of the main indicators of meat's nutritional value. The highest values of this indicator were found in meat samples obtained from the young stock with the ½ D genotype. It is especially worth mentioning (L×LW)×D group, which had by 2.22-2.60% higher values ($p<0.01$) as compared with ½ P young animals, and the (L×LW)×P group, on the contrary, had by1.90-2.60% lower values ($p<0.05$) in comparison with ½ D animals. Similar results as to protein content in D purebred pigs and hybrids of this breed were received by Korean researchers **[68]**. Analyzing the results obtained, it should be noted that the mass fraction of protein largely depends on the total moisture content, since the studied samples were quite lean and the difference in fat content was practically at the same level. This is more likely to be due to the different genetic composition. Still, Chinese researchers **[69]**, having conducted a genome-wide association study of meat quality traits in a three-way crossbred commercial pig population, provide contradictory data: the FarmCPU identified two significant SNPs associated with moisture. Still, the MLM identified no significant SNPs associated with moisture.

Fat mass fraction in the meat of the experimental groups was within 2.14-3.22%, corresponding to physiological standards. It should be mentioned that the difference of this indicator in the samples of pigs with the ½ D genotype obtained from crossing with sows of the direct (LW×L) and back (L×LW) combination made 1.08% but this value is insignificant. However, studies by a group of scientists from Bulgaria have proven a

significant advantage in fat content in the meat of D purebred pigs of the D as compared with P, as well as L and LW, which also participated in the studies. The authors conclude that this indicates that Duroc's participation in crossbreeding schemes is favorable for the phenotypic expression of this trait **[70]**. Other scientists have also proven that the meat of D purebred pigs in comparison with P and other genotypes contains significantly more fat **[71]**, and **[72]**. It should also be noted that the reduction in fat content and increase in protein in meat is consistent with the general trend regarding the place of pork meat in sustainable healthy diets and its further perspective **[73]**.

The physical-chemical analysis of back fat showed that the hygroscopic moisture was within 8.02-9.17% and did not have considerable differences (Table 3). However, it should be mentioned that the fat samples of experimental pigs obtained from sows of the direct (LW×L) combination had somewhat higher values of this indicator than those obtained from sows of the back (L×LW) combination.

Table 3 The results of back fat physical-chemical analysis.

Combination	Hygroscopic moisture, %	Melting point, ºC
(LW×L)×D	9.17±0.63	35.78±0.76
(L×LW)×D	8.12±0.43	36.60±0.59
(LW×L)×P	8.52±0.53	28.96±0.87 *** [1]***
(L×LW)×P	8.02±0.50	30.28±0.79 *** [1]***

Note: ***) $p<0.001$ was calculated for the combination of (LW×L) ×D; [1]***) $p<0.001$ was calculated for the combination of (L×LW) ×D.

A considerable difference ($p<0.001$) was obtained between the groups in the melting point of back fat, namely, the samples from experimental pigs with the ½ D genotype had considerably higher values of this indicator – 35.78-36.60 ºC vs. 28.96-30.28 ºC – of pigs with ½ P genotype. Back fat has a significant content of saturated and unsaturated fatty acids, which are characterized by different nutritional and physical-chemical properties. According to the results of research by some scientists **[74]**, **[75]**, and **[76]** it has been found that purebred pigs of P breed, as compared with D breed, have a higher content of unsaturated fatty acids, which have a lower melting point in comparison with saturated fatty acids, and, accordingly, this affects the general melting point. The analysis of our research results proved a considerable impact of the paternal component on this indicator and, thus, it can be supposed that the back fat sample of pigs with the ½ P genotype also has a higher content of unsaturated fatty acids, which considerably influences this indicator.

Our tasting evaluation of cooked meat from pigs obtained from different variants of interbreed crosses received mixed results (Figure 1). The results' analysis shows that the highest appraisal as to appearance, taste, consistency, juiciness, and general assessment was obtained by the samples of cooked meat from the (LW×L)×P group; only considering the smell, it was 0.16 points lower than in the meat of the (LW×L)×D group. The lowest points for the most signs and the general assessment were received by (L×LW)×D group.

It should be mentioned that concerning palatability qualities, the other samples were estimated equally – 4.33 points indicating their good eating qualities, except for (LW×L)×P group, which received the maximum score of 5 points. Some researchers **[77]**, and **[78]** point out the difference in meat palatability qualities of D and P purebred pigs. In addition, Korean scientists proved that three-way crossbred pigs: (Landrace×Yorkshire)×Duroc and (Landrace×Yorkshire)×Woori black pig synthesized by Korean native breed, had taste differences **[79]**. The other group of Korean researchers proved the dependence of pork flavor compounds as a function of carcass quality grade of (Landrace×Yorkshire)×Duroc crossbred pigs, namely, the pork from high-grade carcasses had a higher content of fat and unsaturated fatty acids, which, according to the scientists, had a positive effect on the tasting assessment of meat and received the highest points **[80]**. Fat content in samples of experimental animals did not have a significant difference between the groups; perhaps that is why we did not observe a clear dependence on this indicator.

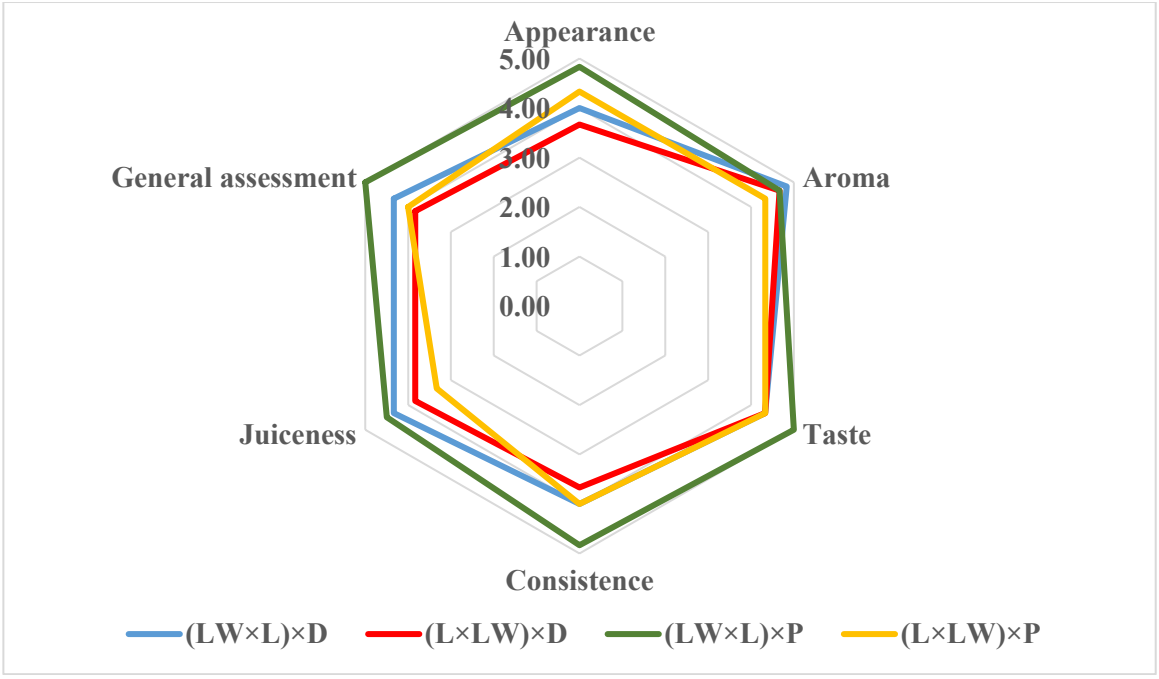

Figure1 The results of organoleptic estimation of cooked meat, points.

The organoleptic assessment results of the broth in which the meat was cooked showed no significant differences between the groups (Figure 2). The taste panel paid special attention to its transparency, so the lowest score was received by (LW×L)×D and (L×LW)×P groups – 3.50 points each, and (LW×L)×P sample was the most transparent – 5 points, which accordingly affected the appearance appraisal. The score for flavor received the highest indicators and varied from 4.50 points – (LW×L)×D to 5.00 points – (LW×L)×P. The taste of the samples received a slightly lower estimate and the animals received the most contrasting appraisal with the ½ P genotype: 4.00 points – (L×LW)×P and 4.83 points – (LW×L)×P. The greatest difference in the assessment of samples distributed by paternal component received the richness index, for example, the animals with the ½ D genotype received 3.67 points each, and with the ½ P genotype: 4.17 points – (L×LW)×P and 4.83 points – (LW×L)×P. It should be mentioned that the general assessment of the samples was quite high, but we also observe that the animals with the ½ P genotype received the most contrasting assessment, for example, the lowest estimate was for the (L×LW)×P samples – 3.83 points, and the highest one, 4.83 points – for the (L×LW)×P samples. The results of the organoleptic estimation of back fat received relatively high values (Figure 3).

Thus, the analysis of the indicators' results shows that the average values were not lower than 4.00 points, proving the high back fat quality in the experimental animals. But it should be mentioned that the highest estimate for all indicators was received by the samples of (LW×L)×P group, the other groups received somewhat less. The taste assessment proved that the highest score was received by the samples of animals with the ½ P genotype, 4.67 points each, (LW×L)×D – somewhat less, 4.50 points, and the lowest value, 4.17 points was received by (L×LW)×D meat samples, which indicates high eating qualities of all the samples regardless of the genotype, since the maximum difference between them was 0.5 points. As it has already been mentioned, the analysis of other indicators proves the advantage of (LW×L) ×P group, only by the indicator of stinginess, the difference between (L×LW)×D group was 0.17 points, as compared with other groups it was, respectively, somewhat higher.

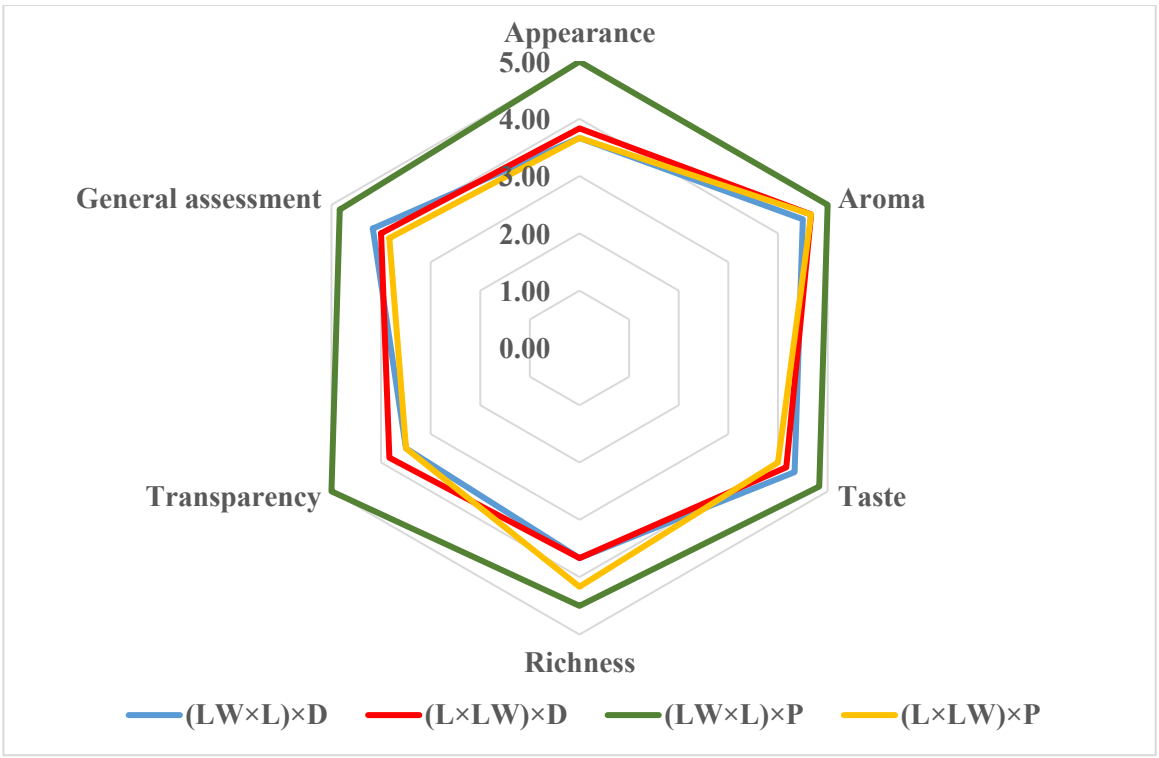

Figure 2 The results of broth organoleptic assessment, points.

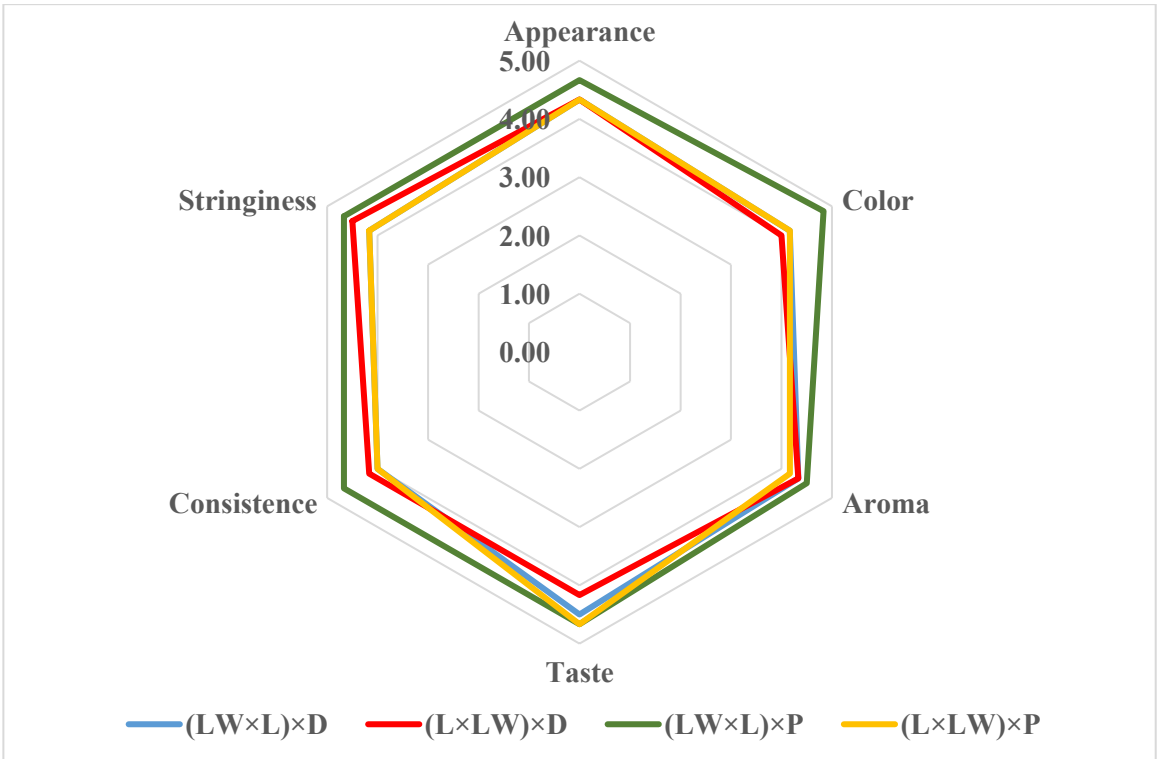

Figure 3 The results of organoleptic estimation of back fat, points.

CONCLUSION

A physicochemical and organoleptic evaluation of meat and fat samples from various pig crossbreeds revealed significant differences in key traits, particularly between the ½ D and ½ P genotypes. Meat tenderness was significantly better in the (LW×L) ×D group, differing by 3.48–3.78 from the ½ P genotype ($p < 0.01$). The active acidity of the meat remained within the standard range (5.69–5.79) for all groups, but the (LW × L) × P group showed slightly higher values than the (LW × L) × D group ($\Delta = 0.1$; $p < 0.05$). The (L×LW) ×P group had the lowest values for the MRP indicator, and compared to (L×LW) ×D, this difference was the largest at 5.27% ($p<0.05$). Cooking losses were also higher in pigs with the ½ P genotype. The (L×LW) ×P group exceeded the (L×LW) ×D group by 3.02% ($p < 0.05$). Pigs with the ½ P genotype also had slightly higher meat moisture content and lower dry matter content. The (L×LW) ×P group had the largest differences in these indicators compared to the ½ D group (Δ=1.02%-1.42%, $p<0.05$). The ash content was higher in ½ P pigs ($\Delta = 0.29–0.34\%$, $p < 0.05$) than in ½ D animals. The largest protein mass fraction was found in meat samples obtained from young animals with the ½ D genotype, besides in the (L×LW)×D group this indicator was by 2.22-2.60% ($p<0.01$) higher in comparison with ½ P young stock; while (L×LW)×P group had the lowest values (Δ=1.90-2.60%, $p<0.05$) compared to ½ D animals. It should be noted that the melting point of fat was significantly lower in pigs from the D breed boar combination ($p<0.001$), indicating better fat quality.

It should also be noted that the use of sows from backcrossing of (L×LW) with different boars ensured the largest contrast values; for example, (L×LW)×D group had the best values in the majority of indicators in contrast to those of (L×LW)×P group, which were somewhat worse. Despite the differences found between the main technological characteristics of meat and lard, the taste analysis of the longissimus dorsi muscle, back fat, and broth did not reveal significant differences and was highly assessed according to all organoleptic indicators.

The conducted studies have proven that the use of these interbreed crosses in the hybridization system does not reduce the quality of pork. According to the results of physical and chemical analysis, all indicators are within normal limits. Still, given the growing requirements of meat processing plants for the quality of pork, we recommend the use of pigs with the (L×LW) ×D genotype for industrial pig farming. Their meat has better nutritional value due to its higher protein content and can potentially reduce the cost of meat products due to its higher moisture retention and lower cooking loss. However, due to the limited sample size of the animals studied, further studies with a larger cohort of animals from different farms are needed to confirm and expand on these results.

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