

PHD DISSERTATION ABSTRACT

Research on the influence of breed, hybrid and exploitation technology is fundamental for optimizing production and adapting it to market requirements, given that the pig, as an omnivorous monogastric species, is considered to be a major consumer of cereals. The combined influence of breed/hybrid and exploitation technology must be analyzed in an integrated manner, as their effects are interdependent. A high-performance hybrid raised in an inappropriate technological system may compromise its potential, and an advanced technology applied to a weak biological material will not produce significant economic results. Therefore, experimental research aimed at identifying the most efficient breed-technology combinations is essential for the development of sustainable and competitive production.

The present research aims to analyze, comparatively, how different pig breeds and hybrids, depending on the breeding technologies applied under production conditions, influence productive performance and carcass characteristics, providing a scientific basis for guiding genetic improvement and technological optimization strategies in modern commercial farms.

The thesis is structured in two major sections, respectively the State of Knowledge in the Approached Field – the bibliographic study prepared based on consulting the specialized literature from the last 10 years on genetics, technologies and performances obtained in the country and in the world in pig breeding and Own research, focused on a series of aspects regarding the organization of the experimental protocol, the dynamics of pig growth and fattening up to the slaughter age, slaughtering performances and carcass classification, physicochemical and nutritional quality of meat, recovery indices resulting from the cutting, deboning and meat selection technique.

Research objectives

To achieve the proposed goal, the following specific objectives were established:

1. Characterization of the genotypes used in the study (purebreds and commercial hybrids (Landrace, Yorkshire, Duroc and their crossbreeds – F1).
2. Determination of the influence of the breed and the hybrid on growth performance, by monitoring technological indices, such as the evolution of body weight from calving to slaughter age, average daily gain (g/day); specific feed conversion (kg feed/kg gain), weight at slaughter age, etc.
3. Comparative analysis of carcass parameters depending on breed/hybrid and the applied growth technology: hot and cold carcass weight, meat/bone ratio, meat/fat, thickness of the back fat layer, dimensional and gravimetric carcass properties; SEUROP classification.
4. Evaluation of the sensory (organoleptic) and physicochemical properties of meat, with emphasis on protein, fat, water and postmortem pH content.

5. Knowledge of the value of some recovery indices resulting from the technique of slicing, boning and sorting meat resulting from the carcasses of the batches of individuals taken into study.

The biological material was represented by 300 female individuals belonging to four different genetic variants, respectively: 75 Landrace sows, 75 Landrace x Duroc sows, 75 Landrace x Yorkshire sows and 75 Landrace x Duroc x Yorkshire sows.

Results on body development by growth stages:

1. Stage 0–28 days (initial starter): All hybrid batches had average weights very close to the LC batch, with insignificant variations (below +0.25%). Batch LE1 recorded the highest value (+0.24%), followed by batch LE3 (+0.10%), while batch LE2 had the same average as the LC batch. The coefficients of variation (CV) indicate good uniformity in all batches (CV < 0.5%). 2. Stage 28–75 days (advanced starter): All hybrid batches exceeded the LC batch in weight: batch LE1 showed a more pronounced advantage (+1.28%). Batches LE3 and LE2 had moderate gains (+0.88%, +0.31%), with batch LE2 standing out with remarkable homogeneity (CV = 1.35%), suggesting genetic stability at this stage. 3. Stage 76–115 days: Hybrid advantages become clearer: LE1 (+1.79%) and LE3 (+1.32%) groups achieved clear progress over LC group, followed by LE2 group with +1.16%. Although LE3 group has a good weight, the variability is slightly higher (CV = 3.56%) compared to LC group. Stage 115–155 days (final fattening): All hybrid groups clearly outperformed LC group: LE1 groups: +1.99%; LE3: +1.38%; LE2: +1.13%. LE3 group recorded the lowest coefficient of variation (CV = 9.87%), suggesting the best uniformity and conversion efficiency in the final growth phase.

Feed conversion results

1. STARTER period (28–75 days) The control group (LC) recorded an ICH of 2.19 kg feed/kg gain, with extremely low variability (CV = 0.23%). The experimental groups presented better ICH values (lower values mean increased efficiency), respectively: group LE1, with 1.99 (–9.10%); group LE2, with 2.06 (–5.94%) and group LE3, with 2.03 (–7.07%). Individuals of group LE1 stood out for the most efficient use of feed, with a reduction of over 9% compared to the control, indicating an optimization of conversion from the beginning phase. 2. GROWTH period (76–115 days) ICH increased, reaching 2.71 within the LC group, with a very low CV (0.20%). The experimental groups continued to improve, as follows: group LE1, by 2.58 (–4.81%); group LE2, by 2.63 (–2.86%); group LE3, by 2.60 (–4.01%). All experimental groups achieved lower ICH values, maintaining a more efficient feed consumption. Variability was kept to a minimum, which reflects the stability of the data. 3. FINISHING period (116–155 days) ICH reached the highest level of all phases: 3.16 within the LC group, which is natural due to the decrease in conversion efficiency towards the end of the growth period. The experimental groups maintained superior performances, registering for group LE1, a value of 2.98 (–5.59%); for the LE2 group, a value of 3.08 (–2.51%), and for the LE3 group, 3.04 (–3.64%). The LE1 group remains the leader in nutritional efficiency at this stage as well, with a consistent reduction in ICH and low variability (CV = 0.20%).

Results on slaughter performance and carcass grading

Hot and cold slaughter yield

All hybrid lots (LE1, LE2, LE3) outperformed Landrace (LC lot) in terms of weights and yields. Lot LE3 (Landrace x Duroc x Yorkshire) stood out with: the highest means for all parameters; the lowest coefficients of variation (CV), indicating superior uniformity; the

best overall slaughter efficiency. The combination of three breeds (Landrace $\times$ Duroc $\times$ Yorkshire) offers the best results in terms of carcass weight and yield, being recommended for intensive production of high-quality pork. The comparative analysis of the four genetic variants (LC = Landrace; LE1 = Landrace $\times$ Duroc; LE2 = Landrace $\times$ Yorkshire; LE3 = Landrace $\times$ Duroc $\times$ Yorkshire) highlights a clear superiority of the LE3 batch, both quantitatively and qualitatively: - The cold carcass weight was the highest in the LE3 batch (68.80 kg), which confirms a better valorization of the post-sacrifice body weight; - The lean meat content expressed in percentages and absolute values was also higher in the case of the LE3 batch (51.39 kg, respectively 74.69%), which denotes a high potential for the production of quality meat; - The removable fat recorded minimum values in the case of the LE3 batch (4.91 kg; 7.13%), which is favorable from a commercial and nutritional point of view; - The meat/fat ratio was the highest in the LE3 group (10.48%), reflecting a superior profile, ideal for the demands of the modern market. The LE3 group (Landrace $\times$ Duroc $\times$ Yorkshire) proved to be the best performer in terms of carcass quality, lean meat content and morphological efficiency. This genetic combination is recommended for breeding programs aimed at increasing meat yield and reducing the proportion of excess fat. The meat/bone ratio, an essential indicator for commercial yield, was the highest in LE3 (4.95%), followed by the LE2 group (4.90%), which - The LE3 group (Landrace $\times$ Duroc $\times$ Yorkshire) recorded the best performances for all the parameters analyzed, indicating a superior carcass value, both quantitatively (weight) and qualitatively (lean meat, meat/bone ratio). This makes the trihybrid combination a valuable option for improving pig production performance, especially in the context of modern market demands for carcasses with high meat content and balanced anatomical proportions.

Dimensional and gravimetric properties of the carcass

The development of the muscle layer at different measurement points at the T1 vertebra level, recorded the highest thickness in the LE2 group (14.83 mm), followed by the LE1 (14.6 mm) and LE3 (14.31 mm) groups, while the LC group (14.20 mm) had the lowest value. Although the LE3 group (Landrace $\times$ Duroc $\times$ Yorkshire) performed better in terms of carcass weight and meat/fat and meat/bone ratios, LE2 excelled in muscle development, an essential aspect in the selection for lean meat and favorable anatomical structure for cutting.

Carcass and hind ham morphological dimensions. Comparative analysis of carcass morphological parameters (carcass length, hind ham length and circumference) for the four genetic groups revealed the following: The LE2 group (Landrace $\times$ Yorkshire) presented the best performances in terms of carcass length and hind hams, indicating a pronounced longitudinal development, favorable from the point of view of commercial yield. The LE3 group (Landrace $\times$ Duroc $\times$ Yorkshire) excelled in hind ham circumference, which reflects a muscular development in volume, particularly valuable for lean meat production, but also showed the greatest variability, which may suggest the need for additional selection for homogenization. The LE1 group (Landrace $\times$ Duroc), although it had the smallest dimensions, stood out for the best uniformity (lower CVs), which makes it valuable from the perspective of morphological stability in large herds.

By applying two methods of estimating muscle tissue content, the results concluded the following: The LE3 group (Landrace $\times$ Duroc $\times$ Yorkshire) provided the best results in both estimation methods (ZP and FOM), confirming a high content of muscle tissue in the carcass, deep musculature and balanced values of the fat layer, which makes it ideal for the

production of lean meat. The LE1 group (Landrace × Duroc) had results close to the LE3 group, especially in terms of a reduced fat layer and good muscle development, being advantageous for stability and efficiency in farms. The LE2 group (Landrace × Yorkshire) had intermediate results, standing out for a balance between fat and muscle, but with values lower than the LE1 and LE3 groups.

Regarding carcass classification, the LE3 (Landrace × Duroc × Yorkshire) group presented the highest proportion of carcasses in the S class (94.67%), confirming the higher level of lean meat and the best overall carcass quality. The LE2 (Landrace × Yorkshire) group obtained 90.67% in the S class, being very close to the LE3 group, with a balanced distribution and only one case in the U and R classes. LE1 (Landrace × Duroc) recorded 88% carcasses in the S class, but also the highest cumulative proportion in the lower U + R classes (5.33%), which suggests a greater variability in carcass performance. The LC (Landrace) group had 89.33% in the S class, but also a presence in the O class (1.33%), which indicates a less performing genetics compared to the hybrid groups, especially compared to the LE3 group.

Results on meat quality obtained in the experiments

● *Sensory analysis*

Sirloin has very high average scores for all characters and in all genetic variants (over 9 for almost all parameters). Loin is similar to sirloin, but with a slight decrease in the case of hybrids. Shoulder has the lowest average scores, especially for appearance and taste. The influence of the genetic group on the sensory quality shows that the hybrid from the LE3 group (Landrace×Yorkshire×Duroc) has the highest overall average scores for most characters (9.66 points for tenderloin, 9.52 points for the flesh). The LC group (Landrace) has good and constant results, with smaller variations (small CV), which suggests a stable quality. If the LE1 group (Landrace×Duroc) recorded some weaker scores, especially for the neck and shoulder, the LE2 group (Landrace×Yorkshire) recorded good scores, but also higher variations in some cases.

- The most appreciated combination from a sensory point of view is for the LE3 group (Landrace×Yorkshire×Duroc), with the highest scores for almost all characteristics and types of meat. The most stable results were recorded for the LC group (Landrace). Regarding taste, the best score was obtained for the chop and tenderloin (scores of 10 points). Shoulder was the least appreciated, especially in appearance and taste.

● *Pork pH*

The Landrace × Yorkshire cross (LE2 batch) repeatedly led to higher postmortem pH values, suggesting a better capacity to maintain meat quality, especially in tenderloin and shoulder. The Landrace × Duroc cross (LE1 batch) generally had the lowest pH values, especially in chop, tenderloin and pulp, which could indicate an acceleration of postmortem glycolysis, with an increased risk of PSE. The LE3 batch (Landrace × Yorkshire × Duroc) presented intermediate values, but close to the LC, suggesting a possible compromise between quality and metabolic stability.

● *Shear force*

The LE1 batch (Landrace × Duroc) frequently leads to increased shear force, therefore to less tender meat, in all anatomical regions. The LE2 (Landrace × Yorkshire) lot tends to maintain WBSF values closer to LC – thus softer in terms of texture. Within the LE3 (triple cross) lot the results were intermediate, but in the shoulder we can see reduced tenderness and high variability. The LE1 (Landrace × Duroc) lot recorded the highest values

in all regions with a significant increase in connective tissue strength; less tender meat. The LE2 (Landrace $\times$ Yorkshire) lot tends to maintain values close to the LC (pure Landrace) lot, suggesting a reduced influence on hardness.

- *Chemical factor values*

The highest water content values for the LE1 (Landrace $\times$ Duroc) lot also systematically determine the best homogeneity in all regions – indicating a favorable genetic combination for juiciness and water retention. The LE2 (Landrace $\times$ Yorkshire) group tends to reduce moisture and increase variability – it can produce drier or unevenly textured meat, and the LE3 (L $\times$ Y $\times$ D) group offers intermediate values, but with slightly higher CV with moderate stability, but not as well-performing as the LE1 group. The LC group had low values in several regions, indicating less hydrated meat, with more limited technological use. The LE1 (Landrace $\times$ Duroc) and LE2 (Landrace $\times$ Yorkshire) groups generally have the highest values for mineral content. In the LE2 group, mineral content predominates in the chop, leg and shoulder, indicating higher potential for functional meat production. The LC (Landrace) group presents the lowest values in all regions, but with relative homogeneity, and the LE3 (triple hybrid) group maintains a balance between high content and variation in the data. The anatomical region significantly influences the protein content: the loin and the chop have the highest content, the shoulder the lowest. Hybrid lots have a more pronounced positive effect on the protein value. Collagen varies significantly depending on the anatomical region, being higher in areas with increased muscle activity (back, neck) and lower in fine muscles (loin, chop). Hybridization influences the collagen content: especially the Duroc hybrids (LE1 lot) seem to slightly increase collagen in some regions (chop, leg, shoulder). Regions with the highest lipid content: Neck and Shoulder. Regions with the lowest lipid content: Loin, followed by leg. Hybridization significantly influences the lipid composition, especially in the fatty regions (back, neck). The energy value is directly proportional to the lipid content, so the neck and shoulder are the most energy dense. The LE2 (Landrace $\times$ Yorkshire) lot tends to accumulate more lipids and, implicitly, to have meat with higher energy values, being more suitable for traditional and industrial products, and the LE1 (Landrace $\times$ Duroc) lot has a lower energy meat, more suitable for diets and health-conscious consumers. The tenderloin is consistently the most dietary segment, regardless of genotype.

Results on recovery indices derived from the slicing, boning and meat selection technique

- *Cutting weight of pieces by anatomical regions and quality classes*

The LE3 (L $\times$ Y $\times$ D) hybrid obtained the best performances regarding total carcass weight (68.8 kg) and a balanced and superior distribution of anatomical regions of commercial interest, suggesting a high genetic value for improving meat production. Regarding quality class I, the LE3 batch had the highest weight (18.59 kg, 27.02%), followed by the LE1 batch (18.31 kg, 26.95%), which shows an increased efficiency in transforming feed into valuable meat. For the II quality regions (shoulder, loin, neck with breast head), all hybrid batches (LE1, LE2, LE3) exceeded the value recorded for the LC batch, both in absolute and relative weight, which denotes better muscle development and morpho-productive balance. The III quality regions (head, legs, drumsticks) had a higher weight for the LC type, which reflects a lower commercial yield, in contrast to the hybrids that recorded lower values, especially the LE3 batch. The data obtained support the conclusion that the

use of advanced hybrids (LE3 and LE1 lots) is recommended in order to optimize carcass quality, maximize profitability and meet market demands for higher quality meat.

- *Boneless weight of the pieces by anatomical regions and quality classes*

The chop, a piece of maximum commercial value, recorded the highest weights in the LE3 hybrid (17.21 kg), followed by the LE2 batch (16.70 kg), which confirms their superiority in terms of quantity and quality. In percentage terms, the meat in the chop was best represented in the LE3 (56.19%) and LE1 (56.08%) batches, highlighting a high muscle yield, while the bone and bacon remained within balanced limits (approximately 10% and 29%). The meat/bone ratio in the chop was the highest for the LE1 batch (5.60), and the meat/bacon ratio also reached a maximum in the LE1 batch (2.02), indicating a superior morpho-productive efficiency in the case of this hybrid.

In the case of ham, the LE1 and LE3 lots presented the highest amounts of meat (over 11.2 kg) and the best meat/bone ratios (6.77–6.84), essential aspects for the sausage and raw-dried products industry. The LE1 lot also obtained the highest meat/bacon ratio in ham (4.65), which underlines an optimal quality profile from a nutritional and economic point of view.

For shoulder, the LE3 lot had the highest total weight (6.47 kg), with a meat content of 2.79 kg and a moderate bacon (1.02 kg), offering a valuable balance between meat, bone and fat. The meat/bone ratio in shoulder was superior to the LE1 (1.49) and LE3 (1.48) lots, which indicates a good slicing yield and fewer processing losses.

In the case of the neck with breast head, the LE3 lot had the highest absolute meat weight (3.14 kg) and a favorable percentage (49.19%), with a meat/bone ratio of 3.40, which recommends it for traditional products or smoked preparations.

Hybridization significantly influences the carcass structure, the LE3 lot (L×Y×D) obtains the highest amounts of meat and chop, but with a slight increase in bacon and bone mass. The LE1 lot (L×D) offers the best meat/bone and meat/bacon ratios, suggesting a more “economical” and commercially viable carcass. The LC lot recorded the worst performances in most parameters, which justifies replacement or genetic improvement through hybridization.

- *Conclusions on tissue composition by anatomical regions*

The connective component (%) recorded the lowest value in the tenderloin (LE3 batch – 8.95%) and the highest value in the neck (LC batch – 31.83%), the latter having a high connective content, which indicates a lower consistency of the meat, useful for processed products (e.g. sausages). In contrast, the tenderloin and the chop are ideally suited for rapid thermal preparation.

The muscle tissue/connective tissue ratio was highlighted in the tenderloin (LE3 batch – 10.17); the minimum value was recorded in the neck (LC batch – 2.14). The ratio highlights the superiority of the tenderloin and the chop in terms of tissue efficiency. Hybrids of the LE2 and LE3 batches offer meat with a ratio optimized for quality and industrial processing.