IMPACT OF INTENSIVE AND EXTENSIVE REARING SYSTEM ON POST-SLAUGHTER LOSSES IN RABBIT MEAT

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Abstract

This study investigates the impact of intensive and extensive rearing systems on post-slaughter losses and physicochemical parameters in rabbit meat. The rabbit carcasses were analyzed, one from an intensive growth system, sourced from a local producer, and the other from an extensive system, obtained according to Romania's National Hunting and Wildlife Protection Legislation (Law no. 407/2006) during the 2023-2024 winter hunting season in hunting ground no. 52, Mironeasa, Iași, Romania. The intensive system carcass followed ISO quality standards as outlined by the Meat Microproduction Department (IULS Iași), while the extensive system carcass was harvested as part of a population control measure. Samples from both carcasses were collected within 24 hours post-mortem, sex and age were recorded, and samples were sealed in sterile bags. They were transported to the laboratory in refrigerated conditions (0-5°C) in accordance with Regulation (EC) no. 853/2004. The research offers a comparative analysis of the post-slaughter losses between the two systems and highlights the differences in handling and processing outcomes based on the growth method. The findings provide valuable data for improving meat quality and minimizing losses in rabbit meat production.

Keywords: rabbit meat, intensive rearing system, extensive rearing system, quality

Rabbit meat offers multiple health benefits for the consumer. Rabbit meat is highly prized for its excellent nutritional characteristics, with less fat, less saturated fat and lower cholesterol levels compared to other commonly consumed meats (Frunză G. *et al*, 2023; Dalle Zotte A., Szendro Z., 2011). Intensive systems generally result in higher final body weight and better feed efficiency compared to free-range systems (Tufarelli V. *et al*, 2022). Alternatively housed rabbits tend to have lower slaughter weights and reduced carcass traits, such as lumbar and hind leg meat weights (Chodová D. *et al*, 2018).

Free-range systems produce meat that is less susceptible to lipid and protein oxidation, which can increase shelf life and reduce post-slaughter losses (Tufarelli V. *et al*, 2022). Extensive systems also result in higher polyunsaturated fatty acid (PUFA) content, which is beneficial for meat quality(Chodová D. *et al*., 2018). Intensive rearing can suppress immune function, which can increase the risk of diseases such as subcutaneous abscesses, a major cause of meat condemnation (Wu Z. *et al*, 2024; Ferreira A. *et al*, 2014).

Subcutaneous abscesses, often caused by *Pasteurella spp*. and *Staphylococcus aureus*, lead to significant economic losses due to meat rejection during post-mortem inspection (Ferreira A. *et al*, 2014). Extensive systems may result in lower meat quality, but reduce total losses after slaughter due to lower carcass numbers (Theau Clément M. *et al*, 2016). Intensive systems, although more productive, face economic losses due to meat quality issues (Ferreira A. *et al*., 2014).

Comparative analysis of post-slaughter rabbit meat losses between intensive and extensive farming systems reveals significant differences in carcass quality, meat characteristics and economic implications. Intensive systems, characterized by controlled environments and commercial feed, often produce heavier carcasses but may experience higher post-slaughter losses due to factors such as meat quality problems and disease prevalence. In contrast, extensive systems, which allow more natural living conditions, tend to produce weaker carcasses with lower overall losses (Ferreira A. *et al*., 2014; Chodová D. *et al*., 2018; Tufarelli V. *et al*., 2022).

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MATERIAL AND METHOD

In this study, the initial stage involved the collection of biological material, represented by two rabbit carcasses subjected to further analyses. The first carcass originated from an intensive farming system, purchased from a local producer. The second carcass was obtained from an extensive system, in accordance with the provisions of Law no. 407/2006 on hunting and the protection of game resources in Romania, and was harvested during the 2023–2024 winter hunting season from hunting ground no. 52, Mironeasa, Iași County. The carcasses were transported under controlled refrigerated conditions (4°C). The regions affected by gunshot wounds were excised to eliminate potential negative effects on sample quality. The selected anatomical regions were cleaned of connective tissue, bones, fat, and tendons.

Compositional analyses (fat, moisture, protein, and collagen content) were performed using the Omega Bruins Food-Check (NIR) spectrophotometer (Bruins Instruments GmbH, Puchheim, Germany). The NIR technique, which operates at wavelengths between 700 and 2500 nm, enables rapid and precise measurements through specific interactions between electromagnetic radiation and biological compounds. The pH values of the samples were determined using a Testo 206-pH1 digital pH meter equipped with an integrated temperature probe. Before each measurement, the electrode was calibrated and rinsed with distilled water to ensure accuracy. The pH data were recorded automatically, and each measurement was repeated for validation.

All experiments were conducted in five replicates. Results are presented as mean ± standard deviation. Statistical analysis was performed using two-way analysis of variance (TWO-WAY ANOVA) with IBM SPSS Statistics, version 21. Statistical differences were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

The results presented in *table 1* highlights the significant differences in the initial weight, final weight, and resulting losses across various anatomical regions of rabbit carcasses between intensive (I) and extensive (E) rearing systems. Rabbits from the intensive rearing system (I) consistently show significantly higher initial weights across all anatomical regions compared to those reared extensively (E). For instance, the forelimbs weigh 300.1 ± 0.47 g in the intensive system compared to 225.2 ± 2.20 g in the extensive system. Similar trends are observed for regions such as the hind shank, shoulder, and rib-eye/loin area. This difference may reflect the better-controlled feeding and growth conditions typical of intensive systems, which result in higher carcass development. He final weight after processing also favours the intensive system for all anatomical regions. For example, the rib-eye and loin area is 120.1 ± 0.447 g in the intensive system, whereas it is only 69.5 ± 0.045 g in the extensive system. The greater retention of weight post-slaughter in the intensive system may be attributed to improved muscle mass development and less pronounced tissue degradation.

Table 1

The initial weight of anatomical regions extracted from rabbit carcasses in intensive and extensive rearing systems, the final quantity and the resulting losses

Rearing system	Forelimbs	Hind shank	Shoulder	Breast	Neck	Flank	Rib-eye and loin area	Tenderloin
Initial weight (g)								
I	300.1± 0.47^{a}	700.8± 1.30^{a}	140± 0.70^{a}	400.8± 1.30^{a}	100.8± 1.30^{a}	160.8± 1.30^{a}	240.2± 0.447^{a}	101.4± 1.943^{a}
E	225.2± 2.20^{b}	431.4± 2.50^{b}	73.8± 1.78^{b}	275.4± 7.98^{b}	75.4± 1.14^{b}	121.6± 2.30^{b}	135.6± 0.045^{b}	60± 0.701^{b}
Carcass quantity after losses (g)								
I	184.6± 0.47^{a}	448.5± 1.30 ^{a}	104.8± 0.70^{a}	342.8± 1.30^{a}	76 ± 1.30^{a}	96.7± 1.30^{a}	120.1± 0.447^{a}	60.9± 1.943^{a}
E	117.4± 2.28^{b}	292.5± 2.50^{b}	55.8± 1.78^{b}	221.9± 7.98^{b}	66.9± 1.14^{b}	76.6± 2.30^{b}	69.5± 0.045^{b}	30.8± 0.701^{b}
Losses (g)								
I	115.4± 1.14a	252.2± 0.35^{a}	35.1± 0.23^{a}	57.9± 0.01^{a}	24.7± 1.35^{a}	64 ± 2.24^{a}	120.1± 2.14^{a}	40.4± 2.14^{a}
E	107.7± 0.56^{b}	138.8± 1.25^{b}	17.9± 0.36^{b}	53.4± 0.45^{b}	8.4± 1.71^{b}	44.9 ± 2.31^{b}	66 ± 2.31^{b}	29.1± 2.34^{b}
Losses (%)								
I	38.47	36	25.12	14.46	24.57	39.85	50	39.85
E	47.62	32.21	24.37	19.42	11.19	36.96	48.65	48.65

Data are presented as means±standard deviation at a significance level of $p < 0.05$. Subscripts on rows indicate significant differences between rearing systems (Intensive vs. Extensive) for each Anatomical Area. I-Intensive; E-Extensive.

Absolute losses are generally higher in the intensive system (e.g., 252.2 ± 0.35 g for hind shank) than in the extensive system (138.8 ± 1.25 g). However, the relative losses as a percentage of the initial weight differ: In the forelimbs, the extensive system shows a higher percentage loss (47.62%) compared to the intensive system (38.47%). This pattern indicates that while the intensive system has higher absolute losses due to larger carcass size, the relative losses are more controlled, reflecting better post-slaughter handling and preservation of carcass integrity. Significant differences in loss percentages across regions suggest varying impacts of rearing systems depending on the anatomical area.

For instance, neck and tenderloin areas show much lower losses in the extensive system (11.19% and 48.65%, respectively) compared to other regions.

Figure 1 shows the evolution of pH in different anatomical regions of the rabbit carcass from an intensive rearing system at specific intervals post-slaughter: 30 minutes, 6 hours, 12 hours, and 24 hours.

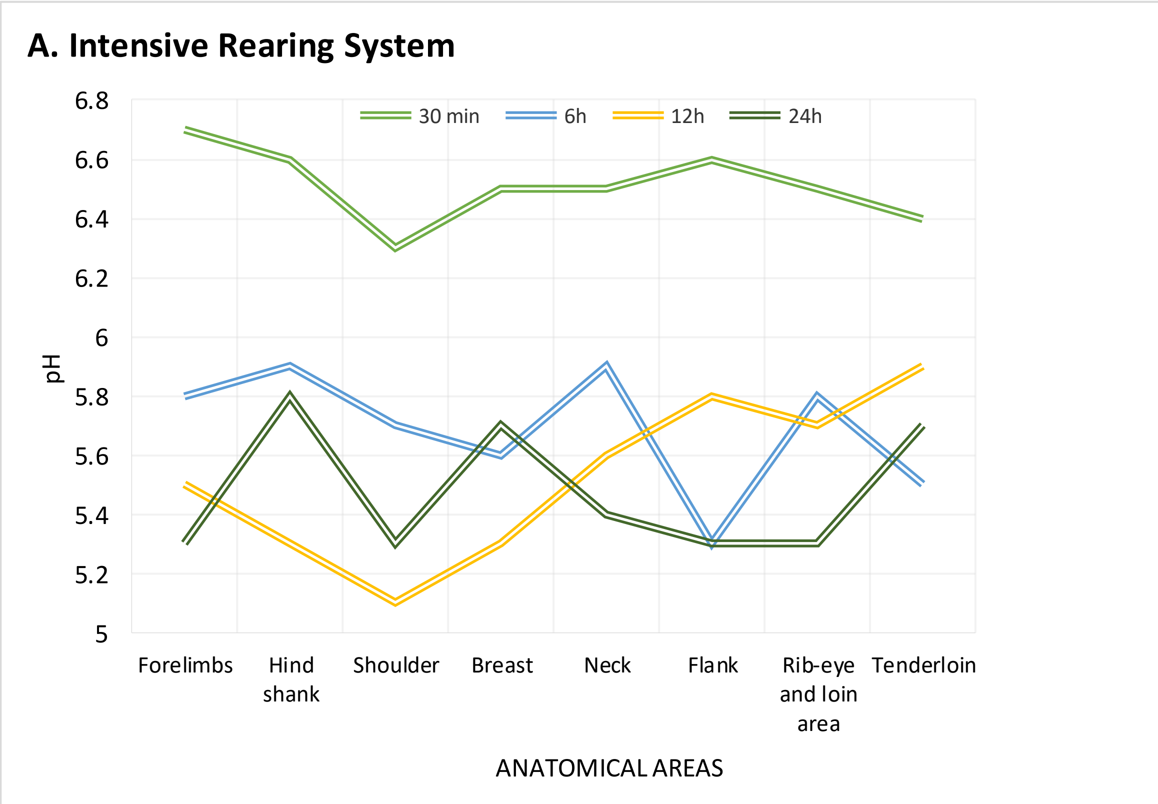

Figure 1 **24h post-sacrifice pH dynamics in intensive rearing system rabbit carcasses**

At 30 minutes post-slaughter, the pH is relatively high across all anatomical regions, ranging from 6.3 (shoulder) to 6.7 (forelimbs). A high pH immediately after slaughter is normal because the muscles are still well-oxygenated, and the process of anaerobic glycolysis (lactic acid production) has not yet significantly begun. Small differences between regions indicate variations in muscle structure and local metabolism. During the interval of up to 6 hours, a rapid decrease in pH is observed in all anatomical regions. For example, in the forelimbs, the pH drops from 6.7 to 5.8, while in the shoulder area, it decreases from 6.3 to 5.7. This decline is caused by the conversion of glycogen into lactic acid through anaerobic glycolysis, which occurs due to the lack of oxygen post-mortem. Differences in pH between regions suggest variations in muscle glycogen reserves and local enzymatic activity. At 12 hours, the pH reaches its lowest values in most regions, indicating the onset of rigor mortis (cadaveric rigidity). The shoulder area records a minimum pH of 5.1, while the flank reaches 5.3. In some regions, such as the tenderloin, the pH begins to increase slightly, suggesting protein degradation and buffering of lactic acid. By 24 hours, the pH stabilizes or increases slightly in some regions, such as the flank (5.3) or the hind shank (5.8). This stabilization is influenced by lactic acid buffering, protein breakdown, and muscle maturation. Forelimbs and rib-eye/loin show a continuous decrease in pH until 24 hours (reaching 5.3), indicating progressive acidification and uniform maturation. Flank and tenderloin display a slightly different trend, with an increase in pH after 12 hours. This behavior may be explained by differences in muscle fiber composition and enzymatic activity. Regions that reach a pH of approximately 5.3 at 24 hours (such as forelimbs and rib-eye/loin) are ideal for obtaining high-quality meat. Higher pH values (>5.5) may be associated with water retention and a softer texture but could increase the risk of microbial spoilage. Regional differences in pH can influence subsequent meat processing. Regions with variable pH require specific adjustments depending on their final use (e.g., aging, preparation).

In *figure 2* the pH values across all regions range between 5.7 (forelimbs, neck) and 5.9 (shoulder, flank, rib eye, tenderloin) in first 30 minutes. This lower pH compared to intensive systems suggests that animals from extensive systems may have had reduced glycogen reserves due to increased physical activity or environmental stress prior to slaughter. Minimal variation between regions indicates relatively uniform muscle metabolism and structure at the onset of *rigor mortis*.

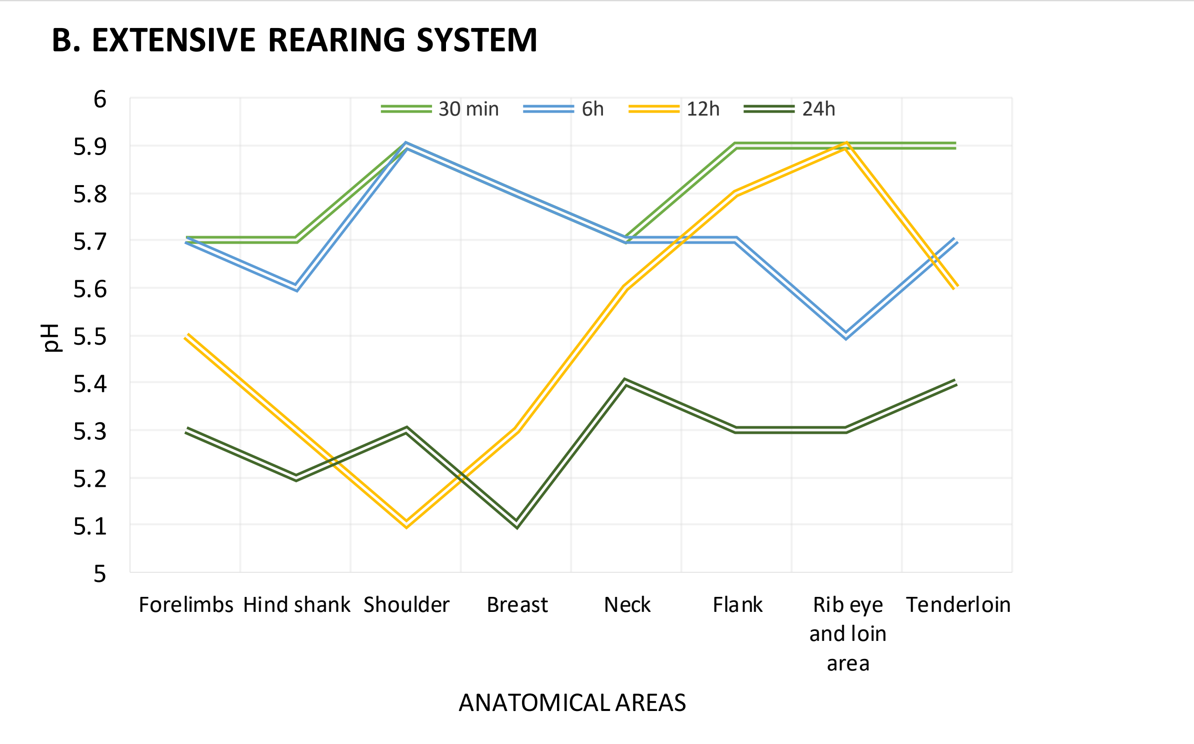

Figure 2 **24h post-sacrifice pH dynamics in extensive rearing system rabbit carcasses**

Between 30 minutes and 6 hours, most regions show little change or a slight decrease in pH. For example, in the forelimbs, the pH remains constant at 5.7, while in the rib eye and loin area, it drops from 5.9 to 5.5. This indicates the onset of anaerobic glycolysis, with lactic acid starting to accumulate due to the depletion of oxygen in the muscles. Differences between regions, such as a sharper decline in the rib eye and loin, may be attributed to variations in muscle fiber type, glycogen reserves, and enzymatic activity. At 12 hours, the pH reaches its lowest values in most regions, coinciding with the establishment of rigor mortis. The shoulder shows the lowest pH at 5.1, while the flank and rib eye and loin exhibit higher values (5.8 and 5.9, respectively). By 24 hours, the pH stabilizes or increases slightly in some regions. The forelimbs, breast, and flank reach a final pH of 5.3, which is suitable for high-quality meat. The tenderloin and neck stabilize at 5.4, while the hind shank declines further to 5.2. Stabilization is due to lactic acid buffering, protein degradation, and the onset of muscle maturation processes. Consistent decline to a final pH of 5.3, ideal for good meat quality. The forelimbs, breast, and rib-eye/loin area display a uniform glycolytic response and acidification. Flank and tenderloin, regions exhibit a delayed or irregular pH decline, potentially due to differences in muscle composition or slower enzymatic activity. The neck retains a slightly higher pH (5.4) due to its mixed muscle fibre composition and potentially lower glycolytic capacity.

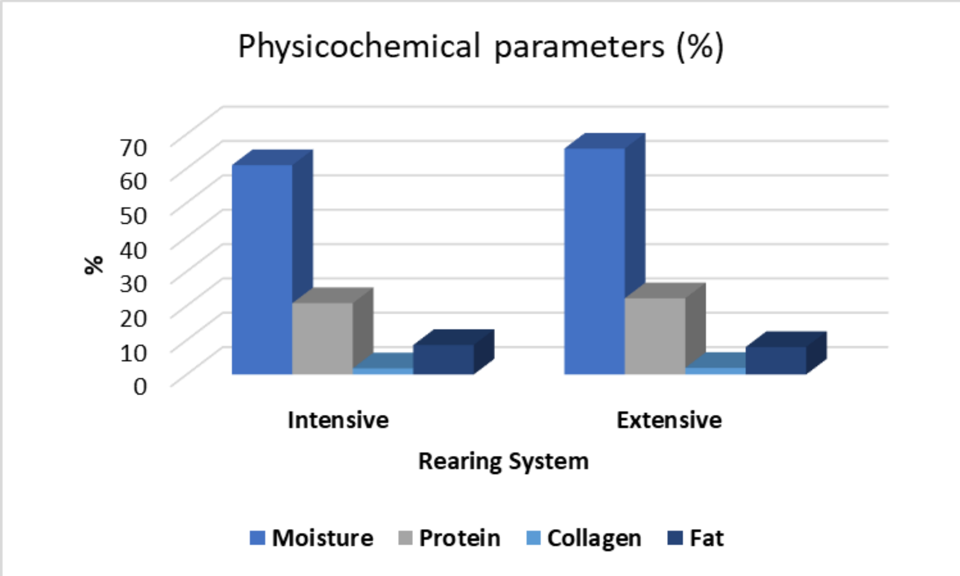

Figure 3 **Physico-chemical parameters in rabbit carcasses from Intensive and Extensive rearing systems**

Figure 3 presents data on the main physicochemical parameters (moisture, protein, collagen, and fat content) of rabbit meat from intensive and extensive rearing systems. These values are expressed as percentages and reflect differences in the nutritional and structural composition of the meat, influenced by the rearing methods.

Samples from rabbit carcasses raised in the intensive system show significantly lower moisture content (60%) compared to those from the extensive system (65%). The higher moisture content in extensively reared rabbits may result from increased physical activity and less developed musculature, leading to higher water retention in the meat. High moisture content can influence the texture and tenderness of the meat, making it softer and juicier. However, excessive moisture may reduce shelf life and increase susceptibility to microbial spoilage.

The highest protein content is observed in the extensive rearing system, which can be attributed to the animal's increased physical activity. Higher protein content is desirable for its nutritional value and indicates superior muscle quality, making meat from the extensive system more appealing to health-conscious consumers. Increased physical activity in extensive systems favors the development of connective tissue, reflected in a slightly higher collagen percentage in samples from the extensive rearing system.

Intensive systems often involve feed with a high-energy content, leading to greater fat deposition. In contrast, extensive systems promote leaner meat due to a lower-energy diet and increased physical activity (Ciobanu M.M. *et al*, 2023).

CONCLUSIONS

In conclusion, the extensive rearing system offers superior nutritional quality meat, with higher protein and collagen content, making it preferred by consumers who emphasize health and sustainability. On the other hand, the intensive system produces meat with a higher fat content, resulting in a more intense flavor, but is less attractive to those who prefer leaner meat. These differences suggest the need for adjustments in the production process and marketing strategies, depending on consumer preferences and market demands. Anatomical regions from carcasses originating in both intensive and extensive rearing systems with variable pH require specific adjustments depending on the final destination of the meat (e.g., during maturation or preparation processes). The intensive rearing system produces larger and heavier carcasses, resulting in more meat yield after slaughter, but also leads to higher absolute losses due to the initial size of the carcasses. The extensive rearing system, on the other hand, shows comparatively lower absolute and relative losses in certain anatomical regions, which may indicate a slower growth rate and denser tissue composition. These findings underline the importance of choosing the rearing system based on specific production goals—whether maximizing yield or focusing on lower post-slaughter losses in certain regions.

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