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Carcass Characteristics and Digestive Organ Weights of IPB D3 Chickens under Different Rearing Systems

R. P. Rambe[1*], A. Furqon[2], S. Darwati[3], & C. Sumantri[3]
[1]Animal Production Science and Technology Study Program Postgraduate School of IPB University, Bogor 16680, Indonesia.
[2]Research Center for Applied Zoology, National Research and Innovation Agency (BRIN), Bogor 16911, Indonesia.
[3]Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor 16680, Indonesia.
*Corresponding author: rzkprimasari@apps.ipb.ac.id
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ABSTRACT

Digestive organs are essential for nutrient absorption and utilization, supporting poultry growth and carcass development. Their performance can be influenced by rearing systems, which also affect animal welfare, productivity, and product quality. This study evaluated the impact of intensive and free-range systems on digestive organ development and carcass characteristics in IPB D3 chickens. Ninety 12-week-old chickens were randomly allocated to two rearing systems (n = 45 per group) for 15 weeks. Observed parameters included ambient temperature and humidity (morning, daytime, afternoon) and weights of the ventriculus, proventriculus, gizzard, pancreas, heart, liver, bile, spleen, and small intestine. Data were analyzed using independent t-tests (α = 0.05). Daytime temperature and humidity differed significantly between systems (P< 0.05), while morning and afternoon values did not (P>0.05). No significant differences were found in ventriculus, proventriculus, pancreas, heart, liver, bile, spleen, and small intestine weights (P>0.05), but gizzard weight was significantly higher in free-range system (P<0.05). Slaughter weight and carcass weight were not significantly affected by rearing system (P>0.05). In conclusion, IPB D3 chickens showed stable digestive organ performance and carcass characteristics under both systems, indicating strong adaptability.

Keywords: Digestive organ, free-range, IPB D3 chickens, carcass

ABSTRAK

Organ pencernaan sangat penting untuk penyerapan dan pemanfaatan nutrisi, mendukung pertumbuhan unggas dan pembentukan karkas. Kinerja organ pencernaan dapat dipengaruhi oleh sistem pemeliharaan, yang juga memengaruhi kesejahteraan hewan, produktivitas, dan kualitas produk. Studi ini mengevaluasi dampak sistem pemeliharaan intensif dan free range terhadap perkembangan organ pencernaan dan karakteristik karkas pada ayam IPB D3. Sembilan puluh ekor ayam berumur 12 minggu secara acak dibagi menjadi dua sistem pemeliharaan (n = 45 per kelompok) selama 15 minggu. Parameter yang diamati meliputi suhu dan kelembaban lingkungan (pagi, siang, sore) dan berat ventrikulus, proventrikulus, gizzard, pankreas, jantung, hati, empedu, limpa, dan usus kecil. Data dianalisis menggunakan uji t independen (α = 0,05). Suhu dan kelembaban siang hari berbeda secara signifikan antar sistem (P< 0,05), sedangkan nilai pagi dan sore tidak berbeda (P>0,05). Tidak ditemukan perbedaan signifikan pada berat ventrikulus, proventrikulus, pankreas, jantung, hati, empedu, limpa, dan usus kecil (P>0,05), tetapi berat gizzard secara signifikan lebih tinggi pada sistem free-range (P<0,05). Berat karkas dan berat saat disembelih tidak dipengaruhi secara signifikan oleh sistem pemeliharaan (P>0,05). Kesimpulannya, ayam IPB D3 menunjukkan kinerja organ pencernaan dan karakteristik karkas yang stabil di bawah kedua sistem, menunjukkan kemampuan adaptasi yang baik.

Kata kunci: Organ pencernaan, free range, ayam IPB D3, karkas, sistem pemeliharaan

INTRODUCTION

Animal welfare is crucial to modern animal farming, especially in producing local chickens. The standards of animal welfare include a comfortable environment, high-quality feed, and proper management practices. Ideal animal welfare not only contributes to the well-being and efficiency of poultry but also impacts the quality of the meat delivered (Du *et al.* 2022). According to Torresi *et al.* (2020), stocking density, ventilation, lighting, and stress management significantly impact poultry welfare. Guaranteeing high welfare standards can upgrade production efficiency and support the maintainability of the poultry industry (Kumar *et al.* 2023). Hence, actualizing ideal animal welfare standards could be an important strategy for improving production quality, keeping up animal well-being, and balancing productivity and ethical considerations in animal farming. Moreover, the management system is pivotal in supporting poultry welfare and productivity. Different farming systems, such as intensive and free-range, are commonly used, each with advantages and challenges. In poultry production, two kinds of rearing systems are used: intensive and free- range. The intensive system involves raising poultry in a controlled-environment housing system with total control over feed, environment, and health, empowering more proficient and uniform production. The advantages of this system include faster growth rates, ease of feed administration, and optimized disease control. However, challenges such as high operational costs and the risk of stress due to restricted space can affect poultry welfare (Tainika *et al.* 2023). On the other hand, the free-range system allows birds to wander in open environments, enabling natural foraging and greater flexibility of movement. This system is considered more animal-friendly because it gives poultry more space for movement. Nevertheless, it presents challenges such as slower growth rates, vulnerability to predators, and potential exposure to environmental diseases (Bonnefous *et al.* 2022). Research shows that poultry raised in free-range systems experience lower stress levels than those in intensive systems. However, the intensive system remains more effective in maximizing meat and egg production and higher carcass quality. Nevertheless, intensive systems remain more successful in maximizing meat and egg production (Fiorilla *et al.* 2023). Therefore, the choice of rearing system ought to consider a balance between productivity, animal welfare, and carcass quality, in line with the rearing targets and environmental conditions, as these components also impact the advancement of poultry digestive organs.

The structure and size of the digestive organs are critical in supporting nutrient absorption in poultry. Well-developed digestive organs show ideal nutrient utilization, which directly affects the wellbeing, growth, and ultimately the carcass characteristics. Feed will be absorbed effectively if the digestive system functions well, which can empower muscle growth and improve meat quality. Organs such as the liver, spleen, small intestine play a critical part within the metabolic process. The liver not only helps absorption but moreover contributes to the production of erythrocytes, which support blood oxygenation and muscle development, whereas the spleen regulates blood adjust and plays a critical part in immune work (Jin *et al.* 2019; Lewis *et al.* 2019). In addition, the size and surface area of the intestinal villi are important variables in nutrient absorption. Increased villus surface area enhances nutrient absorption, improves growth productivity, and as a result, produces better meat and carcass characteristics (Prakatur *et al.* 2019). Environmental variables, such as temperature and seasonal changes, can moreover affect the advancement of the digestive organs and their effectiveness, which straightforwardly affects the anatomical and physiological development of the digestive system and, subsequently, carcass quality (Rostagno 2020). In this manner, understanding the relationship between digestive organ and carcass characteristics is essential to optimize poultry production and achieve optimal results, particularly in nearby Indonesian chickens, such as IPB D3 chickens.

The IPB D3 chicken is a selectively developed line from IPB D1, which has been officially recognized as a local Indonesian chicken under Decree No. 693/KPTS/PK.230/M/9/2019. IPB D3 was developed through crossbreeding between Pelung Sentul male chickens and Kampung Broiler female chickens, with a blood percentage of 25%. The development of IPB D3 chickens is currently mainly focused on intensive rearing system. However, information on the impact of alternative rearing system, such as free-range rearing system on digestive organ is still limited. The maintenance environment plays an important role in shaping the structure and physiological function of the poultry digestive tract (Rostagno 2020). IPB D3 chickens showed good growth performance at slaughter age, with males reaching around 1,256 g and females reaching around 1,042 g (Salsabila *et al.* 2022).

The rapid growth of IPB D3 chickens reflects the efficiency of their digestive system in absorbing nutrients from feed, which ultimately contributes to improved carcass performance. According to Prakatur *et al.* (2019), the morphological development of the digestive tract plays a vital role in nutrient absorption efficiency and is influenced by the rearing system. Several factors affect the weight and development of digestive organs, including feed type and quality, rearing environment, age, genetics, environmental conditions, and dietary additives. Yan *et al.* (2020) stated that rearing systems significantly influence digestive organ development in selectively bred local chickens by altering diet diversity, activity levels, and stress. Additionally, a study by Baryza *et al.* (2025) stated that housing altered carcass traits and gut indirectly, these findings underline the importance of aligning broiler genotype with rearing environment to optimize meat quality. However, previous studies compared different chicken lines under inconsistent rearing conditions, making it difficult to isolate the effects of rearing systems on digestive and carcass development. Therefore, further research is needed to examine how rearing systems influence the characteristics of carcass and digestive organs weights of IPB D3 chickens, a promising superior genetic line.

MATERIALS AND METHODS

Ethical Clearance

This study adhered to animal welfare principles and was approved by the Animal Ethics Committee of the School of Veterinary Medicine and Biomedical Sciences, IPB University, under approval number 209/KEH/SKE/IV/2024.

Materials

The materials used in this study included 90 twelve-week-old IPB D3 chickens and commercial feed. The equipment used consisted of a colony cage measuring 6 m × 1.5 m and a free-range rearing area of 20 m × 10 m, both equipped with feeders, drinkers, and perches. Additional tools for management and organ measurement included leg bands for identification, nets, digital scales, a thermometer, and dissection instruments. Tools used for slaughtering and organ collection included sharp knives, cutting boards, stainless steel trays, scissors, and forceps.

Methods

Preparation of the Free-Range Rearing System

The free-range rearing area measured 20m × 10m and was equipped with commercial feed and natural vegetation, including banana trees, Indigofera plants, and wild grasses. The area was enclosed with protective netting to prevent the chickens from escaping and to protect them from predators. This setup followed the Australian free-range poultry standards, maintaining a maximum stocking density of one chicken per square meter (McCormack 2017). The chickens were allowed to roam freely within this area, enabling natural behaviors such as foraging, ground scratching, and dust bathing, contributing to their overall welfare and health. Additionally, perches made of poles or small trees were installed to facilitate natural roosting behavior, allowing the chickens to rest or perch as per their instincts.

Preparation of the Intensive Rearing System

The intensive rearing system utilized 6m × 1.5m enclosed cages designed to provide optimal living conditions for the chickens. The cages were equipped with an efficient ventilation system to ensure adequate air circulation, helping to regulate temperature and humidity levels. The flooring was designed for easy cleaning to maintain hygiene and prevent the accumulation of waste, reducing the risk of disease and stress among the chickens. Stocking density was carefully managed to avoid overcrowding, ensuring the chickens' comfort. Each cage was fitted with feeders and drinkers, ensuring continuous access to feed and water. Drinking water was provided ad libitum and feed was offered twice daily in the morning and evening with nutritional content as shown in Table 1.

Maintenance and Sample Collection

The IPB D3 chickens reared under both intensive and free-range systems were observed starting at 12 weeks of age, with a total of 90 chickens divided into two treatment groups: 45 chickens in the intensive system and 45 chickens in the free-range system. The chickens were raised for 12 weeks (3 months) in their respective housing conditions. In the free-range system, chickens were allowed to roam freely from 6:00 AM to 5:00 PM, while feed and water were provided twice daily, in the morning (6:00 AM) and in the afternoon (5:00 PM). Temperature measurements were taken daily at three time intervals: morning (6:00–7:00 AM), midday (12:00–1:00 PM), and afternoon (4:00–5:00 PM). In the evening, before sunset, free-range chickens were confined in a 3 m × 3 m shelter to protect them from predators overnight.

Table 1. Nutrient content of feed

Feed Content (%)	12-18 weeks	18-26 weeks
Dry Ingredients	90.53	91.15
Ash	9.3	17.78
Crude Protein	15.98	8.44
Crude Lipid	5.35	6.4
Crude Fiber	15.77	14.02

Source : Proximate analysis of Animal Logistics Indonesia Netherlands (ALIN) IPB

At 26 weeks of age, 30 IPB D3 chickens were selected for organ sampling, consisting of 15 chickens from each rearing system. Before slaughter, the chickens were weighed to determine their slaughter weight. The chickens were then slaughtered by by severing the jugular veins and carotid arteries in accordance with halal slaughter procedures to simultaneously cut the blood vessels, esophagus, and trachea. After slaughter, the abdominal cavity was opened to remove the internal organs, particularly the digestive organs. These organs were carefully separated and cleaned for further examination, and each organ was weighed as part of the digestive morphometric analysis. After slaughter and removal of the internal organs, the carcass weight was measured, including the separation of the feet and head to evaluate the overall carcass quality. The collected data were analyzed to evaluate the effects of different rearing systems on the development of digestive organs and carcass characteristics in IPB-D3 chickens.

Observed Parameters:

The observed parameters included slaughter weight, digestive organ weight, and microclimatic conditions, serving as indicators to evaluate the chickens' response to different rearing systems. The calculations were performed as follows:

1. Measurement of Microclimatic Conditions in the Rearing Environment

Measurement of microclimatic conditions in the rearing environment was conducted by recording temperature and humidity three times a day morning (6:00-7:00 AM), midday (12:00-1:00 PM), and afternoon (4:00-5:00 PM) using a digital thermometer equipped with a built-in humidity sensor. Measurements were taken in both the intensive and free-range rearing systems. The recorded data were then averaged to obtain daily mean temperature and humidity values for each rearing system.

2. Slaughter weight (g)

The slaughter weight of IPB D3 chickens refers to the body weight measured before the slaughtering process. This measurement is taken to determine the live weight of the chickens before being processed, serving as an indicator of growth and rearing efficiency.

3. Characteristic Carcass Weight

Carcass weight of IPB D3 chickens is calculated by measuring the weight of the carcass after slaughter, which includes the edible parts of the body, such as the breast, thighs, and drumsticks, excluding the head, neck, and feet. The resulting carcass weight is expressed in grams. To evaluate the proportion of the carcass in relation to the total body weight, the relative carcass weight of IPB D3 chickens is calculated using the following formula:

$$\text{Carcass Percentage (\%)} = \frac{\text{Carcass Weight (g)}}{\text{Slaughter Weight}} \text{x } 100\% \quad (1)$$

4. Digestive organ weight

The digestive organ weight of IPB D3 chickens includes the weight of individual digestive organs such as the ventriculus, proventriculus, gizzard, and small intestine and accessory digestive organs such as liver, spleen, bile, and pancreas. These organs play a crucial role in digestion and nutrient absorption. The weight of these organs can be influenced by factors such as feed composition, rearing systems (intensive or free-range), and environmental conditions. The relative weight of digestive organs is calculated using the following formula:

$$\text{Organ Percentage (\%)} = \frac{\text{Organ Weight (g)}}{\text{Slaughter Weight}} \text{x } 100\% \quad (2)$$

Data Analysis

The data obtained were analyzed using the T-Test. The T-test was used to determine the differences in the mean values of the carcass, digestive organs measurements and environmental conditions between IPB D3 chickens in free-range and intensive rearing systems.

RESULTS AND DISCUSSION

Microclimatic Conditions in the Rearing Environment

The temperature and humidity conditions in the rearing environment of IPB D3 chickens under both intensive and free-range systems showed significant variations throughout the day during the study period. The following table presents the observed temperature and humidity data recorded during the research period.

The data analysis results regarding environmental conditions in intensive and free- range systems indicate that the daytime temperature in the free-range system was significantly higher than in the intensive system. Additionally, daytime humidity in the free-range system was lower than in the intensive system. These differences suggest that chickens in the free-range system are more exposed to high temperatures from direct sunlight and drier air during the day than those in the intensive system, where the environment is sheltered by a roof that helps regulate temperature and humidity fluctuations. According to Ribeiro *et al.* (2020), the thermoneutral zone for laying hens ranges between 25.9 °C and 29.9 °C, with the optimal comfort range for physiological responses, including cloacal temperature, surface temperature, and respiratory rate between 26.5 °C and 29.9 °C. In contrast, the temperatures recorded in this study ranged from 25.9 °C to 34.56 °C. These findings indicate that the environmental conditions frequently exceeded the upper critical limit of the chickens thermal tolerance. This condition potentially triggers negative physiological responses, as the ambient temperature frequently exceeded the optimal threshold of 29.9 °C.

Lower humidity in the free-range system can lead to faster dehydration, significantly when evaporation rates increase, potentially negatively affecting the chickens' electrolyte balance (Branum *et al.* 2022). A study by Nassar *et al.* (2023) also stated that suboptimal environmental conditions could increase corticosterone levels, an indicator of stress in poultry, while reducing the immune response and growth performance. Therefore, in the free-range system, ensuring an adequate area to maintain their ability to walk normally is essential (Wang *et al.* 2024).

Carcass Characteristic of IPB D3 Chickens

There were no significant differences in slaughter weight and carcass weight between treatments (P>0.05). The slaughter weight and carcass weight of IPB D3 chickens

Table 2. Environmental temperature and humidity conditions observed during the study

Variable	Treatment	
	Intensive	Free Range
	x±sd	x±sd
Temperature (oC)		
Morning (6:00-7:00 AM)	25.9±1.82	25.10±1.68
Noon (12:00-1:00 PM)	31.88±2.73 a	34.56±3.06 b
Afternoon (4:00-5:00 PM)	28.54±2.20	28.17±2.03
Humidity (%)		
Morning (6:00-7:00 AM)	89.90±5.89	90.43±6.02
Noon (12:00-1:00 PM)	66.52±13.02 a	62.93±13.12 b
Afternoon (4:00-5:00 PM)	80.65±6.93	81.17±6.86

Note: $\overline{x}$ represents the mean value of chickens reared under intensive and free-range systems; sd denotes the standard deviation; different superscripts on the same row indicate significant differences (P<0.05).

raised under intensive and free range systems are presented in Table 3.

The statistical analysis showed that different rearing systems (intensive and free- range) had no significant effect on the slaughter and carcass weight of IPB-D3 chickens (P >0.05). The slaughter weight in this study was lower than the results of the study on Habib *et al.* (2020) on IPB D1 chickens, which reached 1.300 g for males and 1.100 g for females at 12 weeks old. Management systems affect carcass traits, where efficient systems enhance body weight gain and dressing percentages (Kaya *et al.* 2024). This was due to differences in the feed provided. In this study, the crude fiber content of the feed exceeded the maximum limit recommended by SNI 7783.2:2013, which is 8%. High dietary crude fiber levels may reduce growth performance and carcass yield. These findings indicate that variations in the rearing environment did not significantly affect the final carcass weight. This may be explained by similarities in other contributing factors such as genetic background, feed quality and composition, and overall management practices across both systems. These findings are in line with the reported by Li *et al.* (2017), which stated that the free-range system resulted in an eviscerated carcass percentage that was not significantly different from the intensive system (P>0.05), indicating that both systems have comparable carcass conversion efficiency. As an illustration, representative images of IPB D3 carcasses under different rearing systems are presented in Figure 1.

Figure 1 demonstrates that IPB D3, as a local chicken breed, exhibits high-quality carcasses under both intensive and free-range rearing systems. According to Hafid *et al.* (2022), the percentage of chicken carcasses is influenced by various factors including genetic differences, maintenance management, rations, chicken age and others. IPB chickens, particularly the IPB D1 line and its derivatives like IPB D3, undergo selective breeding programs focused on high body weight as a primary criterion for superior growth performance (Galib *et al.* 2024). Such carcass quality makes IPB D3 chickens superior in meat yield efficiency, rendering them well suited to a variety of production systems.

Digestive Organ Weight of IPB D3 Chickens

Various factors, including rearing systems and the type of feed consumed, can influence the weight of digestive organs in poultry. Chickens raised under different rearing systems show variations in digestive organ development linked to feed access and physical activity (Yan *et al.* 2020). Table 4 presents the analysis results of the digestive organ weight and percentage of IPB D3 chickens reared under different systems.

The data analysis results in Table 4 indicate that the gizzard weight percentage of IPB D3 chickens was significantly affected (P<0.05). Chickens reared in the free-range system had a larger gizzard than chickens in the intensive system. These findings align with the study by Bari *et al.* (2020), which reported that the outdoor hens showed the higher gizzard weights than the indoor hens. This difference is likely due to because chickens in the free-range system consumed more fibrous and coarse feed materials, feeding different types of commercial concentrates significantly affected the percentages of gizzard (Firmansyah *et al.* 2026). Additionally, chickens reared in the free-range system tend to consume various natural feed sources, such as leaves, insects, and small particles of sand or grit from the soil, which aid in breaking down feed within the gizzard (Takasaki and Kobayashi 2020). High dietary fiber intake contribute to increased gizzard size (Dhakal *et al.* 2024), because fibers have more intensive mechanical digestion, leading to better gizzard muscle activity. The presence of grit accelerates the mechanical digestion process and enlarges the gizzard compared to chickens reared in an

Table 3. Slaughter and carcass weight of IPB D3 chickens reared under different systems.

Variable	Treatment	
	Intensive	Free range
	x±sd	x±sd
Slaughter Weight (g)	1244.27±268.44	1197.13±312.74
Carcass Weight (g)	799.27±169.16	730.80±169.17
Carcass Weight (%)	64.54±7.52	61.82±6.63

Note: $\overline{x}$ represents the mean value of chickens reared under intensive and free-range systems; sd denotes the standard deviation; different superscripts on the same row indicate significant differences (P<0.05).

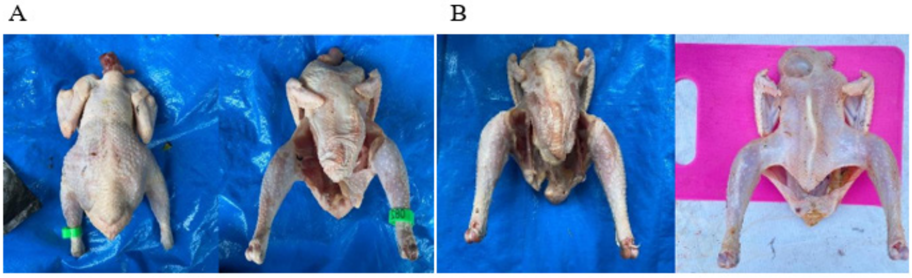

Figure 1. Carcass of IPB D3 chickens from (A) intensive and (B) free-range systems

Table 4. Weight of several digestive organs of IPB D3 chickens reared under different systems.

Variable	Treatment	
	Intensive	Free range
	$\bar{x}$±sd	$\bar{x}$±sd
Ventriculus (g)	6.13±2.08	7.35±2.12
(%)	0.51±0.20	0.62±0.12
Proventriculus (g)	5.58±1.38	5.33±1.54
(%)	0.45±0.11	0.46±0.12
Gizzard (g)	20.19±4.78^{a}	21.67±3.14^{b}
(%)	1.66±0.40^{a}	1.90±0.46^{b}
Pancreas (g)	3.16±0.75	2.68±0.85
(%)	0.26±0.05	0.23±0.09
Heart (g)	6.79±1.40	6.08±1.82
(%)	0.55±0.08	0.52±0.15
Liver (g)	29.85±4.84	26.20±6.11
(%)	2.46±0.47	2.27±0.61
Bile (g)	2.30±0.57	2.00±1.42
(%)	0.19±0.05	0.17±0.11
Spleen (g)	3.15±1.58	3.18±1.38
(%)	0.26±0.13	0.27±0.13
Small intestine (g)	40.57±4.99	39.37±4.52
(%)	3.39±0.77	3.51±1.01

Note: $\bar{x}$ represents the mean value of chickens reared under intensive and free-range systems; sd denotes the standard deviation; different superscripts on the same row indicate significant differences ($P<0.05$).

intensive system with controlled feed. Furthermore, the gizzard weight remained within the normal range. This study is consistent with Whittow (2014), who stated that the normal range for gizzard weight is approximately 1.6%–2.3% of live body weight.

The weight of other organs did not significantly affect, such as the ventriculus, proventriculus, pancreas, heart, liver, bile and small intestine ($P>0.05$), with their weights remaining within the normal range. The small intestine weight was comparable with published values. According to Tabun *et al.* (2021), super native chickens relative small intestine weight ranges from 4.60% to 6.02%. The small intestine is the primary site for nutrient absorption, aided by pancreatic enzymes and bile (Toghyani *et al.* 2020). However, it cannot degrade crude fiber and only hydrolyzes simple carbohydrates for energy. Its remaining within the normal range indicate efficient digestive and metabolic functions. This suggests that IPB D3 chickens adapt well to both rearing systems, maintaining normal digestive organ development. Physiological adaptation to various feed sources and environments helps sustain digestive efficiency (Vertiprakhov *et al.* 2023), meaning significant changes are mainly observed in the gizzard. Thus, both rearing systems did not drastically impact digestive organ weights, demonstrating that IPB D3 chickens exhibit good flexibility in processing feed and maintaining physiological balance.

CONCLUSION

The conclusion of this study indicates that IPB D3 chickens, reared under both intensive and free-range systems are able to maintain optimal digestive organ performance, with organ weights remaining within the normal range. The variations observed in carcass weight and other parameters reflect the adaptability of IPB D3 chickens to different rearing systems. Additionally, the study found that although the rearing system affected gizzard weight percentage, it did not significantly affect the weights of the other digestive organs or carcass characteristics. Suggesting that IPB D3 chickens can maintain consistent carcass characteristics across different management conditions.

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CONFLICT OF INTEREST

We declare that the research we have conducted does not contain any conflict of interest in any form, whether in the form of financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript

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