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Research Article

Evaluation of Growth Performance, Morphometric, Histomorphological Characteristics, and Meat Texture of IPB-D3 Chickens Reared Under Intensive Systems

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Abstract | IPB-D3 chicken is a locally developed fast-growing composite line derived from Pelung, Sentul, Kampung, and Broiler strains. However, the integrated characterization of growth, muscle structure, and meat quality remains limited. This study aimed to evaluate the growth performance, morphometric, histomorphological characteristics, and meat texture of IPB-D3 chickens reared under intensive systems. Chicken body weight was measured once a week, and morphometry was performed every two weeks. Sampling was conducted at 1–3 months of age (n = 5–6 per age group). Chickens were slaughtered using the halal method for carcass analysis, muscle histomorphology, and breast meat texture. The results showed rapid growth performance in IPB-D3 chickens, with higher body weight in males than females and clear sexual dimorphism emerging after 6 weeks of age. The carcass ratio increased significantly, and the breast dominated meat deposition. Fasciculus area and myofiber cross-sectional area increased significantly without changes in the number of myofibers per fasciculus, indicating that muscle growth was dominated by hypertrophy, with a strong correlation between body weight and pectoralis, femoralis, and tibialis muscle parameters. Meat texture showed an increase in firmness, cohesion, gumminess, and chewiness, and a decrease in springiness with increasing age. In conclusion, IPB-D3 chickens exhibit rapid growth with clear sexual dimorphism from 6 to 12 weeks of age, accompanied by progressive carcass improvement and a predominance of breast meat deposition. Muscle growth occurs through hypertrophy that correlates with an increase in meat texture density, indicating efficient growth performance and stable meat texture.

Keywords | Growth performance, Histomorphology, IPB-D3 chicken, Meat texture, Morphometric, Muscle

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INTRODUCTION

The increasing market demand for chicken meat has driven innovations in developing new local chicken breeds and strains that grow to high productivity in a relatively short time (Adelta *et al.*, 2023). Local chickens play a vital role in the rural economy in most developing countries (Padhi, 2016). The superior traits of local

Indonesian chickens form the basis for the creation of new crossbred chickens to meet community needs (Padhi *et al.*, 2016). Composite chickens are developed through crossbreeding multiple breeds to combine desirable parental traits (Prawira *et al.*, 2026). One of the results of this crossbreeding of local Indonesian chickens was the development of the IPB-D3 chicken, originating from a cross between male Pelung-Sentul and female Kampung-Broiler (Cobb parent stock) chickens, in an effort to obtain superior characteristics of local Indonesian chickens through a rigorous selection process (Sumantri *et al.*, 2020). Furthermore, through several generations and selection processes, a fast-growing Indonesian composite chicken strain suitable as parent stock was established, namely the IPB-D3 chicken.

The IPB-D3 chicken has been extensively studied, with research focusing on growth performance, egg production, morphometrics, nutritional supplementation, genetics, immune response, and general histomorphological characteristics (Rahman *et al.*, 2024; Hawari *et al.*, 2024; Galib *et al.*, 2024; Ratnawati *et al.*, 2025; Romantis and Sumantri, 2024; Rizqi *et al.*, 2024, 2025; Vianisa *et al.*, 2025; Kuswandi *et al.*, 2025; Prawira *et al.*, 2026). However, comprehensive histomorphological characterization of skeletal muscle tissue in relation to growth performance, morphometric, and meat texture remains limited. Histomorphological characterization of muscle tissue in IPB-D3 chickens is crucial to understanding the genetic contributions inherited from their parents (Pelung, Sentul, Kampung, and Broiler), as each parental line exhibits distinct muscle fiber composition and growth patterns. Although the muscle structure of each has been reported separately, integrated histomorphological evaluation in IPB-D3 chickens has not been widely investigated.

According to Prawira *et al.* (2026), the first histological characterization of IPB-D3 chickens showed that both free-range and intensive rearing systems yielded similar growth performance. Free-range rearing enhanced muscle hypertrophy and type IIX fiber development, while intensive rearing increases collagen deposition. This indicates that IPB-D3 chickens can adapt to various production environments. However, this study had several limitations, including an unequal sex ratio and a limited sample size. Further studies are needed to comprehensively evaluate growth performance from day-old chicks (DOC) to 3 months of age, morphometrics, detailed muscle histomorphology (pectoralis, femoralis, and tibialis muscles), and meat texture characteristics. Therefore, this study aimed to evaluate the growth performance, morphometric, histomorphological characteristics, and meat texture of IPB-D3 chickens reared under intensive systems.

MATERIALS AND METHODS

Study period and location

The research was conducted from April 2025 to January 2026. The IPB-D3 chickens were housed at the Field Laboratory of Animal Breeding and Genetics, Faculty of Animal Science, IPB University, Dramaga, Bogor, located at approximately 250 m above sea level. Histomorphology analysis was conducted at the Veterinary and Zoology Laboratory, Anatomy and Histology Section, KST Soekarno, National Research and Innovation Agency (BRIN), Cibinong, Indonesia. Breast meat texture analysis was conducted at the Food Laboratory at KST Gunung Kidul (Umar Anggara Jenie), Research Center for Food Technology and Processing, BRIN, Indonesia.

Animal, housing, diet, and experimental design

The study used a total of 65 fifth-generation IPB-D3 chickens, consisting of 5 replications (38 males and 27 females). The chickens were reared intensively under a flock system from day-old chicks (DOC) until 13 weeks of age in indoor cages. The starter house measured 10 × 7 × 3 m, while the grower house measured 32 × 5.14 × 3 m, with each flock maintained in separate enclosures measuring 7 × 2.32 m (starter phase) and 6.5 × 1.85 m (grower phase), containing approximately 30 chickens per flock. The temperature of the cage was set at approximately 28°C. Temperature and humidity were monitored and controlled using a thermometer and an environmental control system. Ventilation was supported by side curtains, which were opened during high temperatures, and exhaust fans operated at 15-minute intervals to improve airflow. Additionally, the litter (husks) was replaced weekly to maintain hygiene. Feeding was conducted in two phases. The starter phase chickens (0–14 days) were fed a commercial diet (Hi-Pro-Vite 511, Phokpand, Indonesia) containing 20% crude protein, 5% crude fat, 5% crude fiber, 0.5% phosphorus, and 0.8–1.1% calcium. The grower phase (15 days to 13 weeks of age) was fed a commercial diet (Hi-Pro-Vite 512, Phokpand, Indonesia), which provided a diet containing 19% crude protein, 5% crude fat, 6% crude fiber, 0.45% phosphorus, and 0.8–1.1% calcium. Feed was offered twice daily (morning and evening), and water was provided ad libitum.

During the rearing process, data were collected on the body weight and morphometric characteristics of each chicken. Body weight was recorded weekly, whereas morphometric measurements were obtained every two weeks. Morphometric measurements included chest circumference, chest width, chest depth, body length, body height, wing length, neck length, thigh length, drumstick length, shank length, tibia circumference, and shank circumference.

Slaughtering and sample collection

Sampling was conducted in the first, second, and third months, with six male chickens initially included at each time point. During the first month, one individual was identified as female and was therefore excluded from the analysis. Consequently, the final number of samples was five, six, and six male chickens for the first, second, and third months, respectively. Sample selection was based on the average weekly body weight of male chickens at the time point closest to the scheduled sampling. The selected chickens were weighed to determine their body weight before slaughter. Subsequently, muscle samples (3 × 3 cm) were excised from the pectoralis (Pec), femoralis (Fem), and tibialis (Tib) before carcass processing. All muscle samples were fixed in 10% neutral buffered formalin (NBF) for 48 h.

Subsequently, carcasses were scalded by immersion in water at 70°C for 10-20 s to remove feathers (Mrajji *et al.*, 2021). Defeathering was performed manually at 1-2 months of age, whereas birds at 3 months of age were processed using an automatic defeathering machine. Carcass and visceral weights were recorded, after which carcasses were partitioned into individual parts, including wings, breast, thigh, drumstick, and back, and each part was weighed separately. Deboning was performed on the breast, thigh, drumstick, and the meat and bone fractions were weighed separately. All samples were stored at –20°C until analyzed.

Histomorphology analysis

Muscle samples from the Pec, Fem, and Tib were processed into tissue blocks using the standard paraffin (Merck, Darmstadt, Germany)-embedding method. The paraffin blocks were sectioned at a thickness of 5 μm using a microtome. The sections were subsequently stained with hematoxylin and eosin (H&E, Merck, Darmstadt, Germany). Slides were observed using an Olympus CX43 microscope at 10× and 20× magnification, and images were captured under standardized brightness and white balance settings. The measured parameters included fasciculus area (FA), myofiber cross-sectional area (MCSA), and the number of myofibers per fasciculus (NMOF) (Yuneldi *et al.*, 2023, 2024; Prawira *et al.*, 2026). The measurements were obtained using ImageJ software (Version 1.53k, National Institutes of Health, USA). Calibration was performed using a micrometer to ensure measurement accuracy. The parameters measured in HE staining included the fasciculus area (average of 10 fasciculus), myofiber cross-sectional area (average of 60 myofibers), and the number of myofibers per mm^2 (5 fields per sample) (Prawira *et al.*, 2026).

Breast meat texture analysis

Meat texture analysis was performed on left breast samples stored at –20°C for 10 days, before analysis, the samples were thawed at room temperature and subjected to texture profile analysis (TPA) using a TA.XT plus C (Godalming, Surrey, UK) equipped with a P/6 probe under the following conditions: double compression to 50% of the sample height, test speed 0.5 mm/s, pre-test speed 300 mm/min, preload force 1.0 N, and a 0.5 s interval between compressions; firmness, adhesiveness, resilience, cohesion, springiness, gumminess, and chewiness were recorded as textural parameters (Hariyadi *et al.*, 2025; Yuneldi *et al.*, 2024).

Statistical analysis

Data were tested for normality (Shapiro-Wilk) and homogeneity of variances (Levene's test) before analysis. Variables that satisfied parametric assumptions were compared using one-way ANOVA. The analysis was confirmed using Duncan's test. When the assumption of homogeneity of variance was violated, Welch's ANOVA followed by the Games–Howell post hoc test was applied. For non-normally distributed data, the Kruskal–Wallis test followed by Bonferroni-adjusted pairwise comparisons. All statistical analyses were performed using Statisty (online platform) and JASP software (Version 0.95.4). Multivariate analysis, including principal component analysis (PCA) and heatmap visualization, was performed using the online ClustVis software (Version 2.0) (Metsalu and Vilo, 2015).

RESULTS AND DISCUSSION

Growth performance and morphometrics of IPB-D3 chickens

Over the 13 weeks, IPB-D3 chickens exhibited progressive growth, with the highest weekly body weight gain occurring at week 2. Final body weight at week 13 was greater in males (1242.87 g) than in females (1020.35 g) (Figure 1). The growth profile of IPB-D3 chickens is relatively rapid. These results are consistent with research by Sumantri and Darwati (2017), who found that IPB-D3 chickens at 10 weeks of age weighed 1256 g for males and 1042 g for females (Salsabila *et al.*, 2022). In fourth-generation IPB-D3 chickens, the average body weight of males at 12 weeks of age was 1021.44 g, and that of females was 684.33 g (Galib *et al.*, 2024). According to Prayogi (2011), this pattern aligns with reports on local Indonesian chickens, such as Pelung chickens, where Pelung chickens weigh 1162 g at 12 weeks of age. The interaction between age and sex indicates that morphology develops progressively with physiological maturation. However, compared with commercial broilers, IPB-D3 chickens exhibit a more moderate yet sustainable growth curve. Modern broilers reach maximum growth rates more quickly, but are often associated with metabolic disorders and myopathy due to extreme hypertrophy (Zuidhof *et al.*, 2014; Petracci *et al.*, 2015).

Table 1: Morphometric comparison between males and females at different ages in IPB-D3 chickens reared under intensive systems.

Variables (cm)	Average SD, Weeks											
	2		4		6		8		10		12	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Chest circumference	9.65 ± 1.27	9.57 ± 1.38	13.09 ± 1.19	12.82 ± 0.69	16.49 ± 1.76*	15.50 ± 1.32	19.48 ± 2.69	18.45 ± 2.25	24.13 ± 2.14**	21.81 ± 1.51	26.39 ± 1.72**	23.98 ± 1.35
Chest width	2.28 ± 0.41	2.27 ± 0.33	3.23 ± 0.32	3.18 ± 0.34	4.18 ± 0.55	4.12 ± 0.45	4.58 ± 0.64	4.69 ± 0.73	5.19 ± 0.54**	4.65 ± 0.58	5.79 ± 0.46*	5.45 ± 0.41
Chest depth	3.27 ± 0.53	3.24 ± 0.57	4.60 ± 0.51	4.57 ± 0.44	6.23 ± 0.60	5.92 ± 0.43	7.45 ± 0.98**	6.62 ± 0.74	8.84 ± 0.60**	7.89 ± 0.67	9.92 ± 0.80**	9.03 ± 0.71
Body length	14.19 ± 1.64	13.87 ± 2.02	19.77 ± 2.22	19.25 ± 1.54	25.17 ± 2.54	25.07 ± 1.33	28.53 ± 2.02	27.95 ± 1.56	34.55 ± 1.85**	32.05 ± 1.24	35.67 ± 1.79**	33.65 ± 1.27
Body hight	18.25 ± 2.21	17.83 ± 2.28	26.88 ± 2.92	25.78 ± 3.02	33.52 ± 2.88	32.95 ± 2.92	38.69 ± 3.14*	37.00 ± 2.72	47.78 ± 3.70**	44.69 ± 2.43	51.73 ± 4.34**	47.25 ± 3.26
Wing length	7.45 ± 0.97	7.53 ± 0.98	10.79 ± 0.85	10.41 ± 0.90	12.41 ± 1.14	12.82 ± 5.07	15.50 ± 1.00	15.10 ± 1.14	18.07 ± 1.26**	16.52 ± 1.08	19.40 ± 2.27**	17.35 ± 1.39
Neck length	3.60 ± 0.61	3.27 ± 0.83	5.23 ± 0.57	5.21 ± 0.49	7.09 ± 0.57	7.11 ± 0.27	8.50 ± 0.93*	7.91 ± 0.96	10.32 ± 1.04**	9.42 ± 0.85	11.80 ± 0.67*	11.34 ± 0.79
Thigh length	3.02 ± 0.52	2.92 ± 0.50	4.30 ± 0.37	4.24 ± 0.31	5.70 ± 0.48*	5.46 ± 0.32	6.69 ± 1.12	6.42 ± 0.59	7.84 ± 0.55**	7.14 ± 0.69	9.23 ± 0.62**	8.56 ± 0.44
Drumstick length	3.78 ± 0.62	3.64 ± 0.62	5.12 ± 0.48	5.09 ± 0.53	6.96 ± 0.69*	6.52 ± 0.89	7.99 ± 0.86*	7.43 ± 0.59	9.58 ± 1.10**	8.61 ± 0.94	11.18 ± 0.73**	10.44 ± 0.64
Shank length	2.51 ± 0.45	2.42 ± 0.45	3.46 ± 0.41	3.42 ± 0.40	4.81 ± 0.47*	4.51 ± 0.42	5.86 ± 0.80	5.60 ± 0.40	7.23 ± 0.81**	6.28 ± 0.52	8.56 ± 0.58**	7.63 ± 0.39
Tibia circumference	2.38 ± 0.52	2.29 ± 0.51	3.40 ± 0.70	3.32 ± 0.77	4.31 ± 0.70	4.33 ± 1.00	5.44 ± 0.76**	4.50 ± 0.77	7.00 ± 1.24**	6.07 ± 0.95	6.83 ± 0.93*	6.15 ± 1.00
Shank circumference	1.75 ± 0.28	1.69 ± 0.41	2.22 ± 0.36	2.23 ± 0.31	2.89 ± 0.46	2.86 ± 0.32	3.33 ± 0.42*	3.08 ± 0.31	3.87 ± 0.48**	3.45 ± 0.36	3.93 ± 0.27**	3.51 ± 0.32

Note: A single asterisk (*) indicates a significant difference at $0.01 \leq P < 0.05$, whereas a double asterisk (**) indicates a significant difference at $P < 0.01$.

Sex-related differences in the morphometric profile became significant at week 6 and increased further at weeks 8 and 12. At 8 weeks of age, chest depth and tibia circumference showed highly significant differences between sexes. By weeks 10 and 12, all measured morphometric parameters differed significantly (Table 1). The increasing morphometric differences between the sexes after week 6 suggest that body-size-based selection may be an effective strategy to improve production performance. The results of this study indicate that the morphometric measurements of IPB-D3 chickens at 12 weeks of age are generally higher than those reported by Rizqi *et al.* (2024), although the observed growth pattern remains consistent. Across all variables, males are larger than females, indicating clear sexual dimorphism in skeletal and muscle development. This difference may be associated with hormonal and genetic regulation of skeletal muscle growth. Androgens, such as testosterone, promote muscle hypertrophy through increased protein synthesis, while growth factors such as IGF-1 support muscle cell proliferation and differentiation. Additionally, differential expression of genes involved in myogenesis may contribute to variations in muscle mass and fiber characteristics between sexes (Emmert *et al.*, 2024; Murach *et al.*, 2023). The chest circumference variable, as an indicator of pectoral muscle development, is directly correlated with meat production potential, so higher values reflect good growth performance.

Principal component analysis (PCA) revealed positive associations among body weight, morphometric, and meat weights of the breast, thigh, and drumstick at 1–3 months of age. The PCA pattern indicated relatively homogeneous clustering at 1 and 2 months, whereas greater variation was observed at 3 months. Heatmap visualization demonstrated that growth performance and meat yield traits at 1–3 months were not directly correlated with testis size (Figure 2). These results are similar to the pattern of more pronounced body weight in 2nd to 3rd months of age in fourth-generation IPB-D3 chickens, indicating accelerated growth after the initial adaptation phase (Galib *et al.*, 2024). Increasing heterogeneity in growth with age has been reported in poultry, with individual growth patterns becoming more diverse after the starter phase (Buzala and Janicki, 2016; Darmani Kuhi *et al.*, 2003), and variation in response to age is influenced by genetic factors between strains (Whittle *et al.*, 2025).

Links Researchers

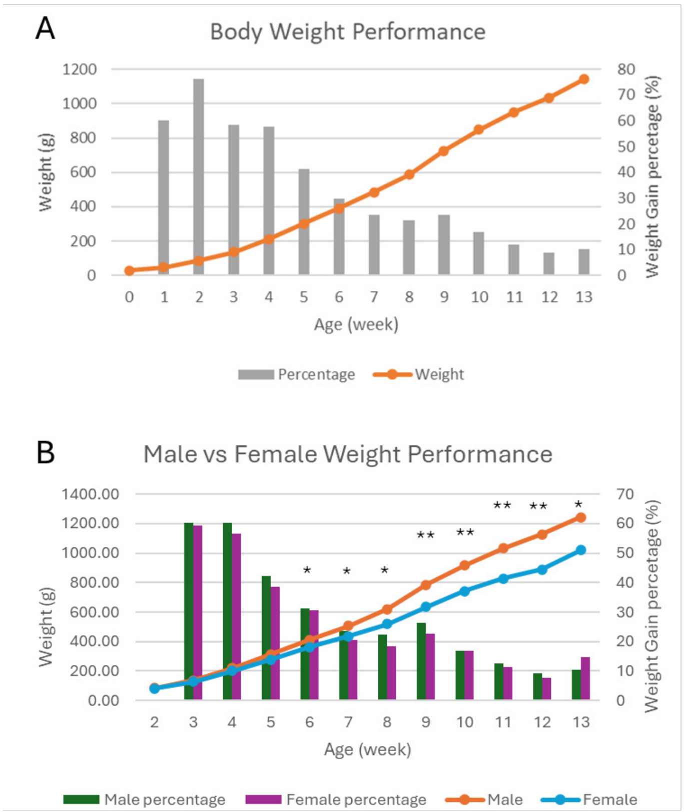

Figure 1: Graph of IPB-D3 chicken growth performance. (A) Body weight and weekly weight gain percentage from week 1 to week 13. (B) Body weight and weekly weight gain percentage of male and female IPB-D3 chickens across age. Asterisks indicate significant differences between sexes (* $p < 0.05$; ** $p < 0.01$).

The carcass ratio increased significantly from 1 to 3 months of age. In addition, carcass ratio to the body part showed a uniform value at 1–3 months of age, but there were significant differences between the three body parts, namely, the breast was generally more than the thigh and drumstick. Thus, the ratio of the amount of meat attached to the bone in these parts showed the thigh part having the most compared to the chest and drumstick (Figure 3). The increase in carcass ratio from 1 to 3 months of age indicates an acceleration in muscle tissue deposition relative to body weight, reflecting a shift in growth priority from organ development to skeletal muscle hypertrophy as the rapid growth phase is reached. During this period, there is an intensive increase in muscle protein synthesis, resulting in a significant increase in the proportion of tissue to carcass weight. These results are consistent with reports by Park *et al.* (2021) and Deng *et al.* (2022), which state that increasing slaughter age is directly correlated with increases in carcass weight and meat yield due to muscular system maturation and increased efficiency of nutrient conversion into muscle tissue. This is supported by other studies that increasing chicken age contributes to increased weight of major commercial cuts, particularly the breast and thigh, which are important determinants of carcass value (Bongiorno *et al.*, 2022; Zuidhof *et al.*, 2014). The dominant contribution of breast meat to the carcass reflects the high hypertrophic capacity of the pectoralis muscle as a major component of the commercial carcass, while the higher meat-to-bone ratio in the upper thigh indicates efficient muscle deposition relative to skeletal growth, which increases slaughter value. These results are consistent with the principle of allometric growth in broiler chickens, where the main muscle groups experience a higher rate of protein deposition compared to supporting tissues, resulting in carcass distribution becoming increasingly concentrated in areas with high economic value with increasing age

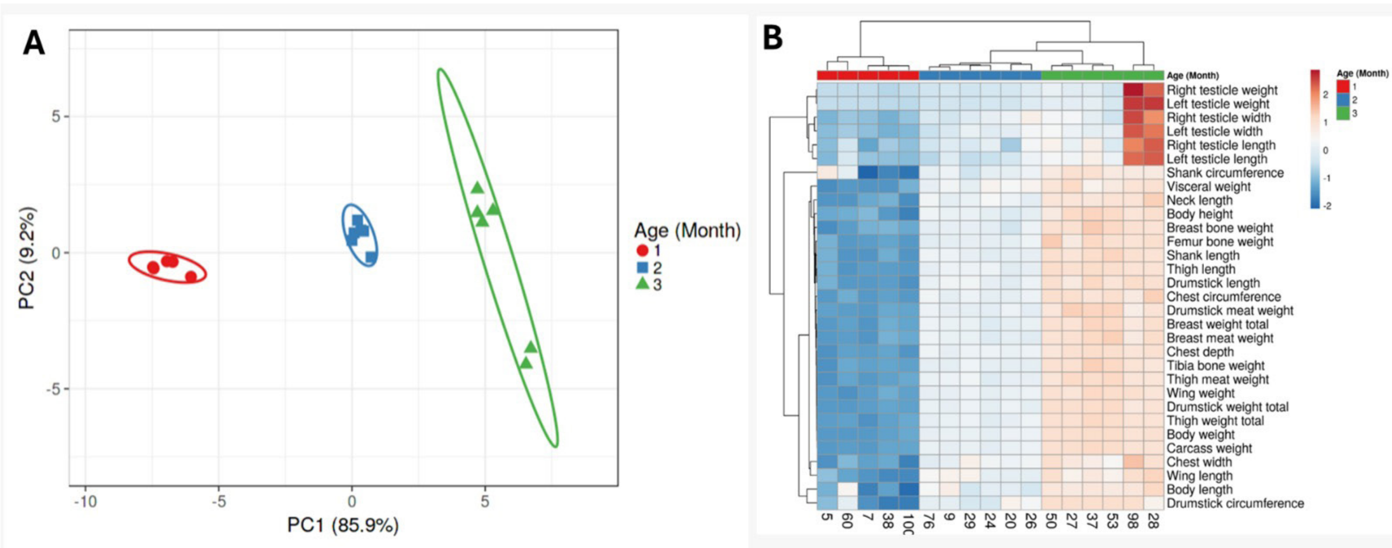

Figure 2: Multivariate analysis of growth performance, morphometric, carcass traits, and testicle of IPB-D3 chickens at 1–3 months of age reared under intensive systems. (A) Principal component analysis (PCA) showing sample distribution based on age and the contribution of measured variables. (B) Heatmap visualization of the correlation patterns among growth, morphometric, carcass traits, and testicle.

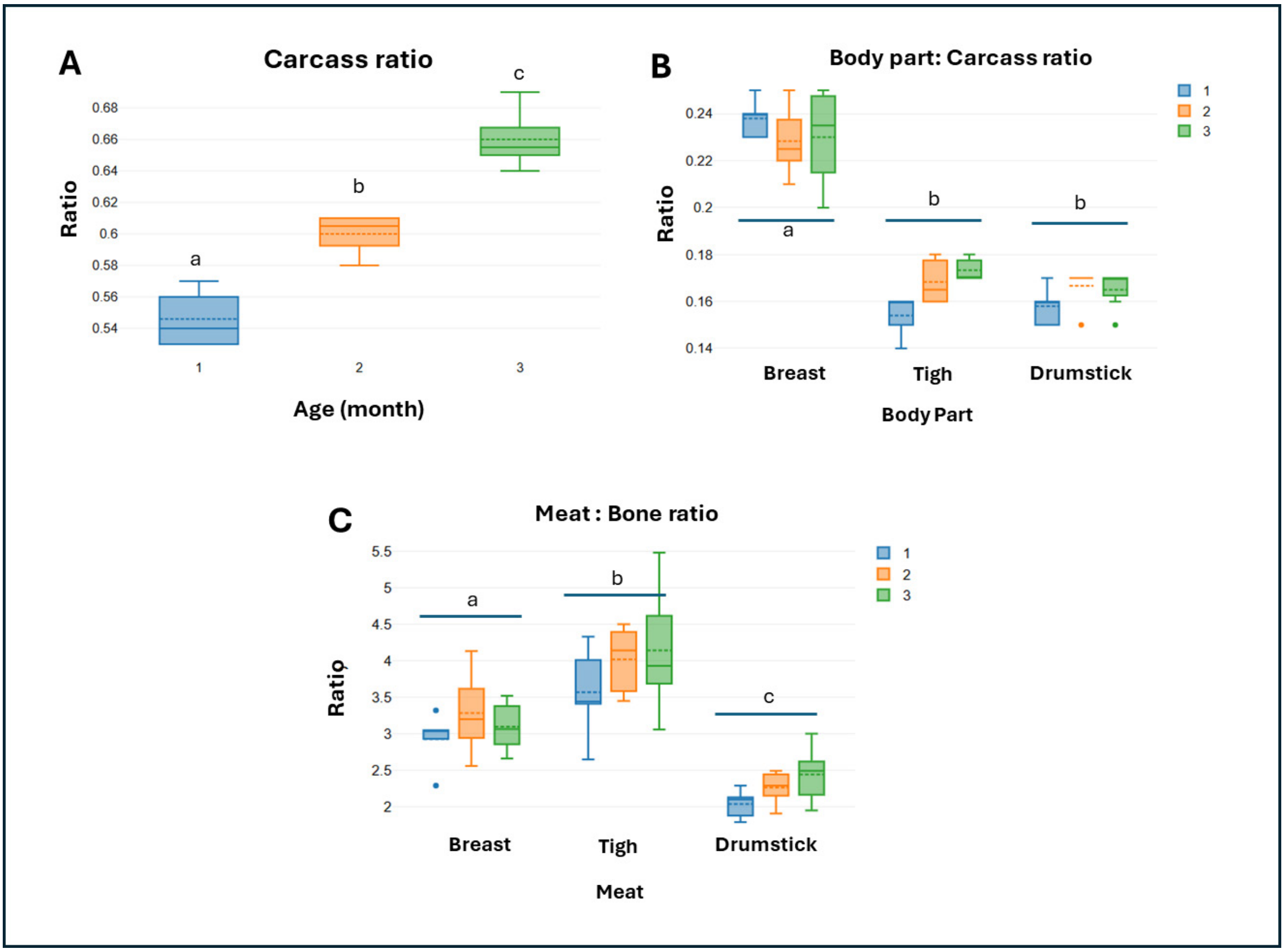

Figure 3: Age-related changes in carcass traits and meat distribution of IPB-D3 chickens reared under intensive systems. (A) Carcass ratio at 1, 2, and 3 months of age. (B) Relative proportion of breast, thigh, and drumstick to carcass ratio (C) Meat-to-bone ratio of individual cuts across ages. Different superscript letters (a–c) indicate significant differences among age groups ($p < 0.05$).

(Park *et al*., 2021; Deng *et al*., 2022). The combination of increased carcass ratio, breast muscle dominance, and thigh yield efficiency indicates that IPB-D3 chickens exhibit an efficient, coordinated muscle growth pattern under intensive rearing systems, thereby supporting their potential as a composite chicken breed with competitive carcass performance.

Histomorphology characteristics and meat texture

Fasciculus area (FA) in the pectoralis (Pec) muscle differed significantly among ages, with a greater increase from 1 to 2 months (2.40×10^4) than from 2 to 3 months (1.64×10^4). In the femoralis (Fem) and tibialis (Tib) muscles, FA at 1 month differed significantly from that at 2 and 3 months. Myofiber cross-sectional area (MCSA) in the Tib muscle differed significantly across all ages. In the Pec muscle, MCSA at 3 months differed significantly from that at 1 and 2 months, whereas in the Fem muscle, a significant difference was observed between 1 and 3 months. For the number of myofibers per fasciculus (NMOF), the Pec muscle differed significantly from the Fem muscle at 1 month. At 2 and 3 months, the Pec muscle differed significantly from both the Fem and Tib muscles (Table 2 and Figure 4). Correlation analysis showed that FA and MCSA were positively and significantly correlated with growth and carcass traits across all muscle parts. In the breast muscle (Table 3), FA and MCSA were significantly correlated with body weight, chest measurements, carcass weight, and breast meat weight ($r = 0.60–0.90$), whereas NMOF showed no significant correlations. In the thigh muscle (Table 4), FA ($r = 0.83–0.89$) and MCSA ($r = 0.67–0.72$) were positively correlated with body weight, thigh length, carcass weight, thigh weight, and thigh meat weight, while NMOF was not significantly associated with these traits. In the drumstick muscle (Table 5), FA ($r = 0.75–0.88$) and MCSA ($r = 0.73–0.88$) remained positively correlated with drumstick length, drumstick circumference, carcass weight , and drumstick weight. In contrast, NMOF showed significant negative correlations ($r = -0.55$ to -0.58).

Table 2: Histomorphology of pectoralis, femoralis, and tibialis muscles at 1, 2, and 3 months of age in IPB-D3 chickens reared under intensive systems.

Variables	Average ± SD, Month		
	1	2	3
FA (x 10^4 µm²)			
Pec	4.74 ± 0.56^{a}	7.14 ± 0.83^{b}	$8.78 \pm 2.44^{c,\alpha}$
Fem	2.89 ± 1.19^{a}	5.62 ± 0.35^{b}	$6.11 \pm 0.61^{b,\beta}$
Tib	2.65 ± 0.18^{a}	5.82 ± 0.61^{b}	$5.85 \pm 0.29^{b,\beta}$
MCSA (x 10^2 µm²)			
Pec	3.74 ± 1.08^{a}	4.55 ± 0.59^{a}	5.82 ± 0.13^{b}
Fem	3.22 ± 0.58^{a}	6.20 ± 1.94^{ab}	7.09 ± 2.96^{b}
Tib	3.29 ± 1.29^{a}	6.76 ± 2.20^{b}	7.82 ± 2.04^{c}
NMOF			
Pec	$132.72 \pm 19.49^{\alpha}$	$143.93 \pm 13.41^{\alpha}$	$150.97 \pm 12.52^{\alpha}$
Fem	$91.92 \pm 28.60^{\beta}$	$100.17 \pm 12.36^{\beta}$	$94.50 \pm 10.16^{\beta}$
Tib	$99.40 \pm 12.70^{\alpha\beta}$	$85.40 \pm 27.68^{\beta}$	$88.10 \pm 5.57^{\beta}$

Different superscripts (^{a,b,c}) within the same row for each variable indicate significant differences ($P < 0.05$). Different superscripts ($^{\alpha,\beta}$) within the same column at the same month and within the same variable (different muscles) indicate significant differences ($P < 0.05$). FA= Fasciculus area; MCSA= Myofiber cross-sectional area; NMOF= Number of myofibers per fasciculus; Pec= Pectoralis; Fem= Femoralis; Tib= Tibialis.

Table 3: Correlation index of chest traits.

Variables	Body weight	Chest circumference	Chest width	Chest depth	Carcass weight	Breast weight	Breast meat weight
FA	0.87*	0.90*	0.81*	0.48	0.87*	0.88*	0.88*
MCSA	0.87*	0.86*	0.74*	0.60*	0.87*	0.88*	0.89*
NMOF	0.31	0.38	0.42	0.06	0.28	0.24	0.23

Note: An asterisk (*) indicates a statistically significant Pearson correlation ($P < 0.05$). FA = Fasciculus area; MCSA = Myofiber cross-sectional area; NMOF = Number of myofibers per fasciculus.

Table 4: Correlation index of thigh traits.

Variables	Body weight	Thigh length	Carcass weight	Thigh weight	Thigh meat weight
FA	0.86*	0.89*	0.84*	0.84*	0.83*
MCSA	0.71*	0.72*	0.68*	0.69*	0.67*
NMOF	-0.07	-0.02	-0.07	-0.08	-0.11

Note: An asterisk (*) indicates a statistically significant Pearson correlation ($P < 0.05$). FA = Fasciculus area; MCSA= Myofiber cross-sectional area; NMOF= Number of myofibers per fasciculus.

The increase in FA and MCSA without changes in NMOF indicates that muscle growth in IPB-D3 chickens is predominantly driven by post-hatch hypertrophy. This mechanism is widely recognized in poultry, where postnatal muscle growth primarily occurs through fiber hypertrophy and is closely associated with subsequent meat quality traits

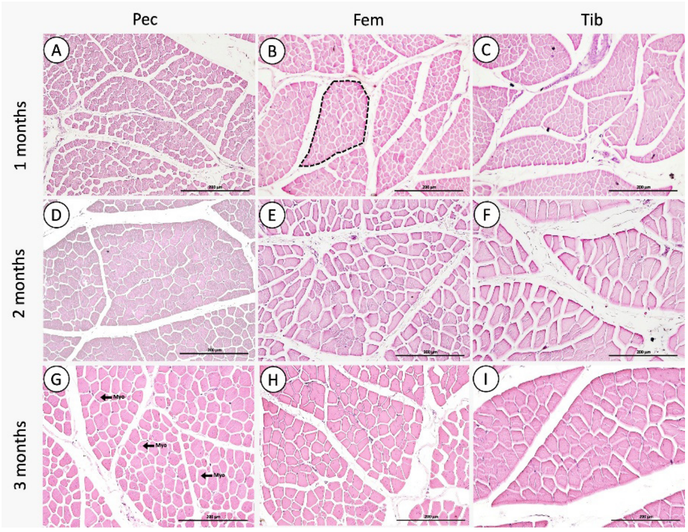

Figure 4: General muscle structure of IPB D-3 chicken from 1 to 3 months of age reared under intensive systems. General structure shown in different muscles of the pectoralis (Pec; A, D, G), femoralis (Fem; B, E, H), and tibialis (Tib; C, F, I). Magnification: 20 × 10. Hematoxylin-eosin staining. Myo=Myofiber, and Dash line=Fasciculus.

Table 5: Correlation index of drumstick traits.

Variables	Body weight	Drumstick length	Drumstick circumference	Carcass weight	Drumstick weight
FA	0.83*	0.88*	0.80*	0.81*	0.75*
MCSA	0.87*	0.83*	0.73*	0.88*	0.83*
NMOF	-0.55*	-0.58*	-0.57*	-0.57*	-0.55*

Note: An asterisk (*) indicates a statistically significant Pearson correlation ($P<0.05$). FA= Fasciculus area; MCSA= Myofiber cross-sectional area; NMOF= Number of myofibers per fasciculus.

(Petracci and Cavani, 2011). This pattern is consistent with the fundamental concept of avian muscle biology, which holds that myofiber number is largely established during the embryonic phase, whereas postnatal growth primarily occurs through the enlargement of existing fibers (Velleman, 2015). The strong correlations between histomorphology parameters and carcass weight further support a direct structural association between muscle microstructure and production performance. Zhang *et al.* (2024) reported that muscle fiber characteristics are key determinants of carcass yield and quality, with hypertrophy representing the dominant growth mechanism under intensive rearing systems. Such progressive hypertrophic growth appears to maintain tissue architectural integrity, in contrast to the extreme growth patterns often observed in commercial broilers (Baldi *et al.*, 2020). Comparative analyses of FA, MCSA, and NMOF in the Pec and Fem muscles of 24-week-old IPB-D3 chickens reared under intensive and free-range systems, as well as comparisons with broiler, Pelung, Sentul, and Kampung chickens at various ages, have been reported by Prawira *et al.* (2026).

This result in FA, MCSA, and NMOF in the Tib muscle of 12-week-old IPB-D3 chickens (MCSA = 7.82 × 10^2 µm^2; NMOF = 88.01) was lower than that reported for the gastrocnemius muscle of 49-day-old broilers, which exhibited a MCSA of approximately 1,400 µm^2 (≈ 14 × 10^2 µm^2) and 106.1 myofibers per bundle. However, the MCSA of the Tib muscle in IPB-D3 chickens was higher than that reported in 12-week-old Sentul chickens, in which the drumstick muscle showed an MCSA of approximately 28.99 µm ≈ 6.6 × 10^2 µm^2 . These comparisons highlight the variability in muscle fiber dimensions among chicken genotypes, which are influenced by genetic background, age, nutrition, and muscle type (Honda *et al*., 2019). Gu *et al*. (2024), emphasized that accurate measurement of the total number of myofibers (TNM) is essential for developing effective genetic selection strategies aimed at improving meat quality. Meat quality is closely associated with histomorphological and biochemical muscle characteristics (Rehfeldt *et al*., 2000; Wegner *et al*., 2000). Understanding fiber size variation is therefore critical, as larger muscle fibers are generally associated with reduced tenderness due to increased muscle density (Joo *et al*., 2017).

Table 6: Breast meat texture of IPB-D3 chickens reared under an intensive system.

Variables	Average ± SD, Month		
	1	2	3
Firmness (N)	1.86 ± 0.13[a]	3.52 ± 1.91[ab]	4.65 ± 1.61[b]
Adhesiveness (g.sec)	-0.12 ± 0.03	-0.10 ± 0.04	-0.17 ± 0.07
Resilience (%)	15.68 ± 0.82	17.07 ± 2.00	17.66 ± 1.13
Cohesion	0.47 ± 0.05[a]	0.53 ± 0.03[b]	0.53 ± 0.02[b]
Springiness (%)	84.76±8.02[b]	77.93 ± 4.96[b]	67.66 ± 4.83[a]
Gumminess	86.13±8.43[a]	192.54±106.87[ab]	249.47±88.15[b]
Chewiness	72.07±9.86[a]	141.89 ± 73.25[ab]	169.84±65.56[b]

Different superscripts ([a,b]) within the same row indicate significant differences at P < 0.05.

Table 7: Correlation between breast meat texture and pectoralis muscle microstructure.

Variables	Firmness	Adhesiveness	Resilience	Cohesion	Springiness	Gumminess	Chewiness
FA	0.69*	-0.53*	0.48	0.37	-0.73*	0.67*	0.60*
MCSA	0.54*	-0.53*	0.33	0.31	-0.68*	0.52*	0.45
NMOF	0.45	-0.06	0.54*	0.70*	0.00	0.49*	0.54*

Note: An asterisk (*) indicates a statistically significant Pearson correlation (P < 0.05). FA= Fasciculus area; MCSA= Myofiber cross-sectional area; NMOF= Number of myofibers per fasciculus.

Texture analysis of the breast meat showed an increasing trend from 1 to 3 months of age. Significant differences (P < 0.05) were observed between 1 and 3 months, where firmness, cohesion, gumminess, and chewiness increased, whereas springiness decreased at 1 and 2 months compared with 3 months (Table 6). Correlation analysis revealed moderate associations between microstructure muscle characteristics and meat texture variables (Table 7). The texture of IPB-D3 chicken breast meat showed a progressive increase in firmness (1.86 to 4.65 N), gumminess (86.13 to 249.47), and chewiness (72.07 to 169.84), accompanied by a decrease in springiness (84.76 to 67.66%) from 1 to 3 months of age. This profile reflects an increase in tissue deformation resistance in line with muscle structural maturation. Myofiber hypertrophy likely enhances the contribution of myofibrillar components to load-bearing capacity; however, mechanical properties are not determined solely by fiber diameter. Intramuscular collagen within the perimysial–endomysial compartments plays a central role in determining hardness and chewiness during maturation (Wattanachant *et al*., 2004; Krzywdzińska-Bartkowiak *et al*., 2016). Structural and physicochemical modifications in muscle fibers and connective tissue are associated with variations in meat texture (Krzywdzińska-Bartkowiak *et al*., 2016). Progressive collagen cross-link stabilization increases tissue stiffness and reduces elasticity (Nishimura, 2010; 2015; Purslow, 2018; Zhu *et al*., 2023). Although collagen was not directly quantified, previous findings in intensively reared IPB-D3 chickens reported increased intramuscular collagen deposition (Prawira *et al*., 2026), which may explain the greater mechanical resistance observed in this study. Compared with other chicken types, IPB-D3 exhibited texture values that were higher than those typically reported for commercial broilers but lower than those observed in older or slow-growing local breeds. In Pelung chickens aged 40–56 weeks, reported values were hardness 134.43 N, springiness index 0.667, and chewiness 29.08 N (Yuneldi *et al*., 2024). Similarly, Bangkok chickens at 3 months showed hardness 177.44 N and a springiness index of 0.52 (Sidiqi *et al*., 2023). In contrast, male commercial broilers at 42 days showed substantially lower values. Ross 308 exhibited hardness 22.6 N, cohesiveness 0.4, springiness 1.6 cm, chewiness 13.8 N×cm, and gumminess 8.5 N, whereas Cobb 500 showed hardness 15.8 N, cohesiveness 0.4, springiness 1.8 cm, chewiness 9.5 N×cm, and gumminess 5.4 N (Kokoszyński *et al*., 2022). These differences reflect the combined effects of growth rate and connective tissue maturation on the mechanical properties of meat. Overall, advancing age and connective tissue maturation are positively associated with increased meat stiffness in IPB-D3 chickens.

Another factor influencing the texture of IPB-D3 chickens is the scalding procedure (70°C). According to Wattanachant *et al*. (2005), this heating process has the potential to increase absolute firmness values through protein denaturation and collagen shrinkage. However, because all groups underwent the same procedure, this effect did not influence the pattern of relative differences between ages. The texture profile of IPB-D3 chickens indicates that the increase in firmness and chewiness, and the decrease in springiness during the 1–3 months of growth, primarily reflect the interaction between myofiber hypertrophy and the gradual, steady maturation of intramuscular collagen.

Certain limitations should be acknowledged. Scalding (70°C) was performed prior to plucking, which may have influenced the breast meat texture profile. Future studies should avoid scalding or apply standardized processing conditions to enable more accurate comparisons of texture parameters. Additional analyses, including mineral composition of meat and bone, collagen evaluation using picrosirius red or Masson's trichrome staining, immunohistochemical detection of myostatin and MYH1, and molecular assessment of related gene expression, are recommended to provide a more comprehensive understanding of muscle development and meat quality.

CONCLUSION

It can be concluded that IPB-D3 chickens exhibit a relatively rapid growth pattern, with clear sexual dimorphism: males consistently attain higher body weight and superior morphometric development than females from 6 weeks of age onward. Carcass yield increased progressively with age, primarily driven by enhanced breast muscle deposition, while the thigh maintained the highest meat-to-bone ratio. Muscle development was predominantly characterized by hypertrophy, as evidenced by enlargement of the fasciculus area (FA) and myofiber cross-sectional area (MCSA) without changes in the number of myofibers per fasciculus (NMOF). These microstructural adaptations were associated with progressive modifications in breast meat texture, including increased firmness, cohesion, gumminess, and chewiness, along with reduced springiness. The findings demonstrate consistent growth performance and progressive structural development of meat properties up to 12 weeks of age under Replaced with intensive rearing systems.

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NOVELTY STATEMENT

Previous studies on IPB-D3 chickens have reported growth performance, body morphometrics, carcass traits, and muscle characterization of the breast, thigh, and drumstick. However, the texture properties of breast meat have not been previously investigated. In addition, earlier muscle characterization studies used unequal sex ratios and small sample sizes, and no comprehensive data are available on the characteristics of breast, thigh, and drumstick muscles at 1, 2, and 3 months of age. Therefore, the present study provides the first integrated evaluation of growth performance, morphometric traits, carcass characteristics, detailed histomorphological muscle features, and breast meat texture of IPB-D3 chickens at 1, 2, and 3 months of age reared under intensive systems.

AUTHOR'S CONTRIBUTION

AYP, RFY, IK, AF, DL, NLPRP, WK, RPR, PV, HSR, MAR, RR, TP, AA, and CS contributed to the conceptualization of the study, experimental design, data collection, sample collection, and manuscript revision. AYP conducted data processing and statistical analysis. AYP and RFY performed the histomorphology sample analysis and drafted the manuscript. All authors read and approved the final version of the manuscript.

Ethical approval

All research procedures were approved by the ethical clearance of the National Research and Innovation Agency (BRIN), Indonesia (Approval No. 191/KE.02/SK/09/2025).

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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