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Comparative evaluation of five commercial broiler feeds on carcass traits in Indonesia

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ABSTRACT

The research aimed to evaluate effect of various commercial feeds on broiler carcass traits. Three hundred unsexed DOC broilers Cobb strain with body weight of 46.68±0.86 g were allocated in completely randomized design with 5 treatments and 6 replications. The treatments applied were providing commercial feed from 5 different producing companies in Indonesia, including prestarter, starter and finisher, produced during 2022 and used by partnership companies as follows: Commercial feed produced by companies A, B, C, D and E. Maintenance carried out according to the partnership company's SOP. Data collection was carried out at 29 days. Parameters observed included carcass production (live weight, carcass weight and percentage, breast meat percentage, non-carcass weight and percentage, abdominal fat percentage), and carcass quality (carcass grade, whole carcass price, total feed costs and Gross Carcass Profit (GCP). Obtained data were analysed for variance. Commercial feed of companies A and D produced significantly higher breast meat percentage ($P<0.05$) than feed from company B. On the other hand, the commercial feed of company B produced significantly higher abdominal fat percentage ($P <0.05$) compared to other commercial feeds. Live weight, weight and percentage of carcasses and non-carcasses were not significantly influenced by treatments ($P>0.05$). Feeding commercial feeds from companies A and D significantly resulted in higher GCP ($P<0.05$) compared to feed from company B. Providing commercial feed B and C resulted in a significantly higher total feed cost ($P<0.05$) compared to feed from companies A, D, and E. Whole carcasses price and grade were not significantly influenced by treatments ($P> 0.05$). It could be concluded that commercial feed produced by companies A and D provides the best results for broiler carcass traits.

Introduction

Feed represents the largest investment in broiler poultry farming, both in independent and contract farming systems. Feed costs account for approximately 60–80% of the total production expenses in a single production cycle (Azizah *et al*., 2013). Commercial broiler feeds available on the market vary in composition and formulation, tailored to meet the nutritional requirements of broilers and to optimize performance based on feed ingredient availability (Sufiriyanto *et al*., 2018). Protein sources constitute the largest cost component in feed production due to their reliance on imports, which results in fluctuating prices (Falah *et al*., 2022). Consequently, the prices of commercial feeds vary across different products. Based on our survey, the price differences among pre-starter, starter, and finisher feeds ranged from 1.3–7.4%, 0.2–2.9%, and 0.9–7.9%, respectively. These considerations require contract farmers to carefully select feed products in order to achieve efficient performance and high-quality broiler carcass production.

Variations in nutrient composition may affect broiler growth characteristics as well as carcass traits. Among the nutrients, protein and energy are particularly critical for broiler growth and development. Protein is essential for feather formation, tissue repair, and overall development, particularly for muscle protein deposition in the breast area (Anggitasari *et al*., 2016), and its dietary requirements must be adequately met (Harahap *et al*., 2020). Energy, on the other hand, is required to support growth, physical activity, and thermoregulation, as it encompasses the metabolism of carbohydrates, fats, and proteins (Azua *et al*., 2022). Energy intake also plays a regulatory role in feed consumption; once the bird's energy requirement is fulfilled, feed intake tends to decrease or cease (Jannah *et al*., 2021). These nutritional factors are crucial considerations when selecting commercial feeds, as they directly influence the efficiency of broiler growth and the resulting carcass quality.

Evaluating commercial broiler feeds available in the market is essential to determine their value in relation to carcass performance and an economic perspective. A previous study by Anggitasari *et al*. (2016) compared four different commercial feeds, but only evaluated a single feeding phase and assessed performance at 35 days of age. The feeds tested had varying crude protein contents (20.02%; 20.43%; 20.88%; 22.68%) and metabolizable energy levels (3,133.50; 3,199.11; 3,221.15; 3,395.27 kcal/kg), which led to differences in carcass and breast meat percentages. Similarly, Sogunle *et al*. (2009) reported that broilers fed a commercial starter feed containing 23.70% protein and a finisher feed containing 19.45% protein yielded a breast meat percentage of 17.28% and abdominal fat percentage of 1.27%. These findings indicate that nutrient variation in commercial feeds can result in differences in broiler carcass characteristics. Unlike previous studies that only focused on a single feed phase, the present study comprehensively evaluates the effects of commercial feeds across all feeding phases pre-starter, starter, and finisher from five different feed manufacturers. The study not only assessed the impact of these commercial feeds on broiler performance but also linked economic aspects (Gross Carcass Profit) and carcass quality, which are rarely evaluated together in commercial feed studies.

Materials and methods

All procedure was applied under approval of FAAS Diponegoro ethical commitee (No 59-06/A-14/KEP-FPP). The study was conducted at the Poultry Production Laboratory , Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang. A total of 300 unsexed Cobb-500 day-old chicks (DOC) were obtained from PT Malindo Feedmill, Grobogan, with an average initial body weight of 46.68±0.86 g. The chicks were randomly allocated into 30 experimental units and reared in open-sided, deep-litter floor pens using rice husk bedding. Commercial feeds for the pre-starter, starter, and finisher phases were sourced from five different commercial feed manufacturers in Indonesia, labeled as Companies A, B, C, D, and E. These feed products were those commonly used by contract farmers under PT Mustika Jaya Lestari and were produced during the

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March–April 2022 production batch in Central Java province. The nutrient composition of the feeds used in the study is presented in Table 1.

A Completely Randomized Design (CRD) was employed, consisting of five treatments with six replications each. Each experimental unit contained 10 broiler chickens. The treatments involved the provision of commercial feeds during the pre-starter, starter, and finisher phases from five different feed manufacturers, labeled as Companies A, B, C, D, and E. Bird management was carried out according to the standard operating procedures (SOP) of the contract farming company, PT Mustika Jaya Lestari. The feeding schedule for the commercial diets was as follows: pre-starter feed was given from day 1 to 9, starter feed from day 10 to 21, and finisher feed from day 22 to 28. Carcass processing was conducted on day 29. bird representing each experimental unit was selected and slaughtered using the Modified Kosher method (according to Islamic law). Scalding was performed using a semi-scalding technique followed by manual wet plucking. Carcass and non-carcass components were weighed and recorded for further analysis. Live body weight was measured prior to slaughter by weighing broiler chickens that had been fasted for 8 hours. Carcass and breast weight were recorded after removal of non-carcass components and evisceration. Abdominal fat was obtained by separating the fat attached to the abdominal cavity and digestive organs. The breast meat was separated and weighed individually. All sample data including carcass weight, non-carcass weight, abdominal fat, and breast meat were calculated as a percentage relative to live body weight, representing carcass production parameters.

Carcass quality parameters included carcass grade, whole carcass price, and Gross Carcass Profit (GCP). Carcass grading was assessed based on USDA (2018) standards, which evaluate conformation, fat cover, meatiness, feather cleanliness, bone integrity, and skin condition. Grades were assigned numerically, with Grade A = 3, Grade B = 2, and Grade C = 1. The final grade was determined by the lowest score among the assessed criteria.

Whole carcass price and GCP were determined based on the average broiler carcass prices from June to December 2022, as published by the Directorate General of Livestock and Animal Health Services (Ditjen PKH) on the SIMPONI-Ternak website. The carcass price was calculated following Nggena *et al*. (2019) by multiplying carcass weight by the price per kilogram. GCP was calculated according to Biesek *et al*. (2022) as the difference between total carcass revenue (carcass weight × price per kilogram) and total feed cost during the rearing period. Feed cost was determined by multiplying the prices of pre-starter, starter, and finisher feeds by the corresponding feed intake.

"GCP=" ("Carcass Weight" ("kg"))" x Carcass price per kg)-" ("Feed intake" ("kg"))"x Feed price per kg)"

Additional data, such as performance indicators and protein utilization, were also observed and analyzed to support a more comprehensive evaluation. These results are presented in Table 5. Data that did not follow a normal distribution were transformed prior to analysis of variance. Statistical analyses were performed using IBM SPSS Statistics version 25. When significant differences among treatments were found, Duncan's Multiple Range Test was conducted as a post-hoc analysis.

Results

Broiler carcass production

The analysis of variance revealed that the type of commercial feed significantly influenced the percentage of breast meat and abdominal fat in broiler chickens, while other carcass parameters remained unaffected. Broilers fed with commercial diets from Companies A and D exhibited significantly higher breast meat percentages ($P<0.05$) compared to those receiving feed from Company B. However, breast meat percentages in broilers fed diets C and E did not differ significantly from those in groups A, B, or D. In contrast, broilers receiving feed from Company B showed the highest abdominal fat percentage, followed by those from Company A. These two groups had significantly higher abdominal fat percentages ($P<0.05$) compared to broilers fed diets C, D, and E. No significant differences ($P>0.05$) were found in live body weight, carcass weight, carcass yield, non-carcass weight, or non-carcass percentage among the different feed treatment groups. The complete results of the effects of different commercial feeds on broiler carcass production are presented in Table 2.

Carcass quality and economic analysis

Broilers fed diets A and D demonstrated superior carcass quality in Gross Carcass Profit (GCP), which was significantly higher ($P<0.05$) than in broilers receiving feed B. No significant differences were found in GCP for diets C and E compared to other groups. Income Over Feed Cost (IOFC) was highest in groups A and D, indicating better feed efficiency and economic return. Total feed cost was significantly higher ($P<0.05$) in broilers

Table 1. Nutrient composition of feeds used in different feeding treatments.

Type of Feed	Treatments	Moisture (%)	Ash (%)	Fat (%)	Crude Protein (%)	Crude Fiber (%)	Ca (%)	P (%)	ME (kkal/kg)[c]
	T1	11.69	5.05	4.92	21.1	3.5	0.64	0.55	3152.23
	T2	10.88	5.37	4.77	20.97	2.82	0.8	0.6	3187.12
Pre-starter[a]	T3	10.08	5.58	5.85	24.74	3.22	0.79	0.65	3241.79
	T4	10.05	5.13	5.72	22.26	2.88	0.69	0.59	3265.14
	T5	10.76	4.98	4.43	21.16	2.4	0.74	0.56	3205.05
	T1	11.27	4.82	5.18	21.36	3.54	0.61	0.52	3185.43
	T2	11.07	5.58	4.66	20.42	3.27	0.84	0.63	3152.06
Starter[a]	T3	10.45	4.99	5.1	21.33	3.17	0.7	0.57	3218.1
	T4	9.96	5.43	6.48	20.82	3.62	0.73	0.55	3265.14
	T5	10.35	4.93	5.67	19.82	2.8	0.69	0.56	3262.21
	T1	11.78	4.49	7.95	18.26	2.19	-	-	3447.85
	T2	11.53	4.37	6.39	19.13	1.29	-	-	3423.71
Finisher[b]	T3	10.27	5.28	8.13	19.9	2.79	-	-	3460.1
	T4	10.14	5.77	8.05	20.73	1.39	-	-	3493.47
	T5	10.9	5.2	5.89	18.55	2.08	-	-	3366.37

[a]Nutrient analysis using Near Infrared Reflectance Spectroscopy (NIRS) was conducted by PT. Japfa Comfeed Indonesia, Grobogan Unit (2022). [b]Proximate analysis was carried out by the Laboratory of Feed Nutrition Science and the Laboratory of Beef and Draught Animal Production, Diponegoro University, Semarang (2022). The symbol (–) indicates that calcium (Ca) and phosphorus (P) were not analyzed. [c]Metabolizable Energy (ME) was calculated using the following formula: $ME = 40.81 \times \{0.87 \times (CP + (2.25 \times EE) + NFE) + CF\}$ (Sugiharto et al., 2018) Where: CP: Crude Protein; EE: Ether Extract (Fat); NFE: Nitrogen-Free Extract; CF: Correction Factor, which is 2.5 for young poultry and 4.9 for adult poultry.

fed diets B and C compared to those on diets A, D, and E, despite similar live body weight and carcass weights. This suggests feed consumption and formulation affect economic efficiency. Whole carcass price and grade did not differ significantly among treatments (P>0.05), aligning with non-significant variation in carcass weight and live body weight. These results indicate that while carcass weight and conformation were consistent across treatments, the nutritional profile and protein efficiency had a substantial impact on key carcass traits, specifically breast meat and abdominal fat percentages, and on production profitability.

Discussion

The higher breast meat percentage in broilers fed commercial feeds from Companies A and D compared to Company B likely stems from several factors. First, variation in dietary protein content among feeds resulted in significantly different (P<0.05) levels of total protein intake (Table 3) in quality and quantity. Second, protein intake differences affect amino acid availability for muscle protein deposition, crucial for optimal muscle hypertrophy in the breast region. Third, differences in energy-to-protein ratios across feed types influenced protein utilization efficiency, affecting

Table 2. Broiler carcass production resulting from the feeding of various commercial feeds.

Parameter	T1	T2	T3	T4	T5	P-value
Live weight (g)	1.568.17±34.25	1.463.67±42.78	1.604.83±37.74	1.629.67±87.18	1.469.33±31.38	0.09
Carcass weight (g)	1.118.67±29.26	998.67±41.34	1.099.17±28.18	1.140.00±72.25	1.041.83±29.19	0.16
Carcass percentage (%)	71.32±0.78	68.15±1.33	68.53±1.21	69.84±1.46	70.87±0.90	0.24
Breast meat percentage (%)	27.90±0.64a	24.85±0.80b	25.66±0.95ab	27.56±0.70a	25.64±0.65ab	0.03
Non carcass weight (g)	449.50±14.75	465.00±17.66	505.67±24.77	489.67±27.98	427.50±13.16	0.09
Non carcass percentage (%)	28.68±0.78	31.85±1.33	31.47±1.21	30.16±1.46	29.13±0.90	0.25
Abdominal fat percentage (%)	1.93±0.03b	2.68±0.08a	1.54±0.04c	1.60±0.06c	1.43±0.08c	<0.005

Different superscripts in the same row indicate significant differences (P<0.05). T1 = commercial feed A; T2 = commercial feed B; T3 = commercial feed C; T4 = commercial feed D; T5 = commercial feed E

Table 3. Broiler carcass quality due to the provision of various commercial feeds.

Parameter	T1	T2	T3	T4	T5	P-value
Carcass grade	2.67±0.21	2.50±0.22	2.67±0.21	2.83±0.17	2.67±0.21	0.86
Whole carcass price [1)] (Rp×10^2)	380.17±9.94	339.40±14.04	373.55±9.58	387.43±24.56	354.07±9.92	0.16
Total feed cost[1)] (Rp×10^2)	173.83±0.58b	180.94±0.24a	182.07±0.20a	170.85±1.20b	171.98±2.44b	<0.005
Gross Carcass Profit[1)] (Rp×10^2)	206.52±10.16a	158.46±14.16b	191.48±9.58ab	217.14±24.07a	182.08±8.96ab	0.04

Different superscripts within the same row indicate significant differences (P<0.05). T1 = commercial feed A; T2 = commercial feed B; T3 = commercial feed C; T4 = commercial feed D; T5 = commercial feed E; [1)]Cost per bird.

Table 4. Energy and protein intake at different phases.

Type of Feed		T1	T2	T3	T4	T5	P-value
Pre Starter[1)]	Energy (Kkal×10^2)	8.11±0.02d	8.25±0.04c	8.37±0.01ab	8.46±0.01a	8.27±0.06bc	<0.005
	Protein (g)	54.31±0.12c	54.34±0.29c	63.93±0.02a	57.69±0.04b	54.64±0.40c	<0.005
	Rasio E/P	149.39	151.98	131.03	146.68	151.47	
Starter[1)]	Energy (Kkal×10^2)	29.30±0.13b	28.93±0.04c	29.66±0.01a	29.78±0.14a	29.71±0.15a	<0.005
	Protein (g)	196.51±0.87a	187.42±0.26c	196.63±0.06a	189.94±0.91b	180.52±0.91d	<0.005
	Rasio E/P	149.13	154.36	150.87	156.83	164.59	
Finisher[1)]	Energy (Kkal×10^2)	37.30±0.18a	37.17±0.04a	37.71±0.08a	37.21±0.44a	35.38±0.96b	0.02
	Protein (g)	197.55±0.94c	207.70±0.24b	216.92±0.48a	220.82±2.60a	194.97±5.28c	<0.005
	Rasio E/P	188.82	178.97	173.87	168.52	181.48	
Total[1)]	Energi (kkal×10^2)	74.72±0.24ab	74.36±0.10ab	75.76±0.09a	75.46±0.56a	73.37±1.06b	0.04
	Protein (g)	448.38±1.43b	449.47±0.60b	477.48±0.50a	468.45±3.41a	430.13±5.91c	<0.005

Different superscripts within the same row indicate significant differences (P<0.05). T1 = commercial feed A; T2 = commercial feed B; T3 = commercial feed C; T4 = commercial feed D; T5 = commercial feed E;[1)]Consumption per broiler.

Table 5. Performance and utilization of protein due to administration of various commercial feeds.

Parameter	T1	T2	T3	T4	T5	P-value
Feed Consumption (g)	2259.30±7.29	2262.74±2.98	2270.31±2.50	2236.68±16.44	2220.06±31.73	0.20
Average Weight Gain (g)	1654.02±15.39ab	1605.87±12.41bc	1591.68±13.62c	1663.92±24.42a	1578.15±23.11c	0.01
FCR	1.36±0.01b	1.41±0.01a	1.43±0.01a	1.34±0.01b	1.40±0.01a	<0.001
IOFC[1)] (Rp)	18464.99±340.93a	16603.50±246.84b	16159.04±295.65b	18958.56±461.30a	16756.94±445.94b	<0.001
Feed Passage (minutes)	209.57±2.06d	218.12±2.88c	224.07±3.27b	230.70±2.38a	195.85±3.61e	<0.001
Excreta Ammonia (ppm/g excreta)	7.40±0.22d	7.87±0.39c	8.62±0.24b	7.17±0.33d	9.58±0.37a	<0.001
Crude protein digestibility (%)	79.25±1.29	78.69±1.85	78.72±2.03	79.88±0.69	79.62±2.27	0.98

Different superscripts in the same row indicate significant differences (P<0.05).
[1)] IOFC is calculated based on the formula: (Live bird weight × Live bird price/kg) - (Feed consumption × Feed price/kg). [2)] Excreta ammonia is measured with a digital ammonia meter

growth rate and contributing to variation in carcass traits among treatment groups.

The variation in protein intake quantity was caused by differences in the protein content of the feeds, even though total feed intake was similar across all commercial feed treatments (Table 5). This finding aligns with the statement of Berliana and Nurhayati (2020), who reported that increased protein intake enhances muscle protein deposition, which is also influenced by the availability of both protein and energy in the feed. The quality of the protein consumed by broilers may also affect the efficiency of breast meat protein deposition. Low-quality protein is more likely to be excreted in waste rather than utilized for muscle synthesis. This is supported by the lower ammonia concentrations ($P<0.05$) in the excreta of broilers fed commercial feeds A and D compared to those fed commercial feed B, as observed in this study (Table 5). Yu *et al*. (2024) suggesting a balanced approach to both CP and AME is crucial for optimal growth and muscle protein deposition. According to Marang *et al*. (2019), feeds with high protein content but low protein quality tend to result in higher ammonia levels in the excreta. It is presumed that the commercial feeds used in this study had different formulations, potentially even across production batches, which may have affected the resulting protein quality. The higher breast meat percentages observed in broilers fed commercial feeds A and D may also be attributed to a more ideal amino acid profile in those feeds. However, this study had a limitation in that amino acid analysis was not conducted. According to Mehri *et al*. (2015), an ideal amino acid composition in broiler diets containing 1.05% digestible lysine (dLys), 0.58% digestible methionine (dMet), and 0.76% digestible threonine (dThr) can optimize breast muscle mass.

Higher total protein intake in broilers ensures sufficient protein availability for deposition in breast muscle during the hypertrophy phase. According to Velleman *et al*. (2014), the hypertrophy process in broiler breast muscle is characterized by an increase in muscle fiber diameter and overall breast muscle mass, and this process continues up to 42 days of age. Therefore, at the observation point of 29 days in this study, the hypertrophic process was still actively occurring, indicating that a higher protein supply during this phase can contribute to an increased breast meat percentage. The differences in breast meat percentage among broilers fed different commercial feeds, despite having similar live weights, suggest that dietary protein intake influences breast muscle hypertrophy. This finding is supported by Powell *et al*. (2013), who reported that breast muscle development is particularly sensitive to protein intake during the hypertrophic phase, due to the proliferation and differentiation of satellite cells into muscle fibers, which enhances protein synthesis and ultimately increases breast muscle mass.

Broilers require different energy-to-protein ratios at each growth phase. Variations in the energy-to-protein ratio across feeding phases can influence the growth and development of carcass components. This is consistent with the findings of Budiarta *et al*. (2020), who stated that carcass component development in broilers begins with bone growth, followed by muscle development, which gradually declines with age and is subsequently replaced by fat deposition. Therefore, the balance between energy and protein in broiler diets must be carefully managed. Data presented in Table 3 shows that the energy-to-protein ratio increases with age. The energy-to-protein ratios of commercial feeds in this study ranged from 131.03 to 151.98 for the pre-starter phase, 149.13 to 164.59 for the starter phase, and 168.52 to 188.82 for the finisher phase. According to Abdel-Hafeez *et al*. (2016), the recommended energy-to-protein ratios for broiler starter, grower, and finisher feeds are 139.58, 159.52, and 176.32, respectively. In relation to this, it is suspected that commercial feeds A and D most closely matched the ideal energy-to-protein ratios at each phase, thereby contributing to the higher breast meat percentages observed in broilers fed these diets.

The percentage of breast meat obtained from broilers fed commercial diets C and E did not differ significantly compared to those fed diets A, B, or D. As shown in Table 5, broilers receiving diet C had significantly higher protein intake ($P<0.05$) than those fed diet A. However, this higher intake did not result in an increased breast meat yield, likely due to the presence of more ideal amino acid availability in diet A. Although the abdominal fat percentage of broilers fed diet C was significantly lower ($P<0.05$) than those given diet A, the data in Table 5 show that diet C led to significantly higher ($P<0.05$) excreta ammonia levels, indicating lower protein utilization efficiency. This is further supported by the significantly higher feed conversion ratio (FCR) ($P<0.05$) observed in broilers fed diet C compared to diet A. A similar pattern was observed in broilers fed diet E, suggesting that both diets C and E were less efficient in supporting breast meat deposition.

The highest abdominal fat percentage (2.68%) was found in broilers fed diet B, which can be attributed to the following reasons: (1) The dietary protein consumed was inefficiently utilized for meat deposition, as reflected in the lower breast meat yield (Table 3); and (2) The protein content of diet B was relatively low across the pre-starter, starter, and finisher phases, contributing to greater fat deposition. Data from Table 3 also show that, despite similar energy intake across treatments ($P>0.05$), broilers fed diet B had significantly lower total protein intake ($P<0.05$) compared to those on diet D, and a similar protein intake to those on diet A ($P>0.05$). This indicates that the dietary protein in diet B was less efficiently utilized, leading to excess energy being stored as abdominal fat. This finding aligns with the study by Jariyahatthakij *et al*. (2018), which reported that broilers at 24 days of age fed diets with varying protein levels but identical metabolizable energy showed significantly increased abdominal fat when consuming lower-protein diets. The relationship between dietary protein and abdominal fat deposition is further explained by previous studies: abdominal fat deposition in broilers is influenced by the de novo lipogenesis pathway, which is regulated by the activity of fatty acid synthase (FAS) in the liver (Fouad and El-Senousey, 2014); and dietary protein levels ranging from 12% to 30% can alter the activity of malate dehydrogenase, which catalyzes oxaloacetate formation and subsequently acetyl-CoA, thereby directing metabolism toward de novo lipogenesis for abdominal fat synthesis (Rosebrough *et al*., 2008).

The significantly higher abdominal fat percentage observed in broilers fed commercial diet B is presumed to be due to the relatively low protein content in the diet, resulting in excess energy that is likely converted into fat through lipogenesis and stored as abdominal fat. This is in line with the findings of Tombuku *et al*. (2014), who stated that excess energy in broilers tends to be deposited as abdominal fat, with the synthesis process itself requiring energy, thus leading to inefficient energy utilization. A high percentage of abdominal fat indicates suboptimal protein deposition in broilers with similar body weight when fed diet B. Conversely, Harumdewi *et al*. (2018) reported that optimal broiler growth is indicated by high protein deposition in breast meat, low intramuscular fat content, and reduced abdominal fat percentage. The significant differences in breast meat and abdominal fat percentages observed in this study are likely influenced by a wider range of energy-to-protein ratios in the commercial broiler diets (Table 3) compared to those reported by Londok *et al*. (2017), which in turn may explain the variations in abdominal fat percentage. Londok *et al*. (2017) suggested that if diets have relatively similar energy and protein levels, such as 3163.59–3041.84 kcal/kg and 21.05–20.16%, they do not significantly affect abdominal fat percentage in broilers. Moreover, differences in abdominal fat percentages may also be attributed to variations in the availability of amino acids in the commercial diets used. This is supported by Qaid and Al-Garadi (2021), who stated that an imbalance in glucogenic amino acids may lead to their conversion through gluconeogenesis, with the resulting excess calories being stored as fat. Srilatha *et al*. (2018) also noted that a high energy-to-protein ratio contributes to increased fat deposition in broilers due to excess energy consumption per unit of protein intake.

Variations in feed formulation and ingredients used in each commercial feed batch result in differing energy-to-protein ratios, which ultimately determine the value of the feed in relation to carcass production parameters in this study. Broilers exhibiting optimal growth performance are characterized by carcasses with higher breast meat percentages and lower fat deposition, as consumers generally prefer carcasses with more breast meat. According to Ayu *et al*. (2020), consumers favor breast meat due to its larger portion size and tender texture. A limitation of this study is the lack of detailed information regarding the specific feed ingredients used during the formulation of each commercial feed batch, which may influence the interpretation of the results. Other carcass parameters including live weight, carcass weight, carcass percentage, non-carcass weight, and non-carcass percentage were not significantly different, likely due to several factors: (1) The growth phase of broiler chickens at this age prioritizes muscle and fat deposition, resulting in slower growth of other body components; (2) Non-carcass components may have already reached their maximum development; and (3) Protein intake sensitivity particularly the quality of protein, such as amino acid balance affects breast meat percentage and abdominal fat more significantly than other carcass components.

Broiler chickens, being a meat-type poultry, exhibit distinct growth patterns across different carcass components. Feed formulations with nutrient profiles aligned with the developmental stages of carcass components can optimize carcass growth. According to Budiarta *et al*. (2020), broiler carcass development begins with bone formation, followed by muscle growth, and subsequently fat deposition as the bird ages. This growth pattern is supported by several studies: bone and muscle growth in broilers significantly increase between 7–21 days of age before slowing down (Megawati *et al*., 2020); varying energy and protein nutrient densities do not significantly affect breast meat percentage between days 1–25 but do so significantly from days 25–42 (Majdeddin *et al*., 2018); and fat deposition increases in line with body weight and age (Saputra *et al*., 2015). These findings support the notion that at 29 days of age, broilers fed different commercial diets are in a growth phase prioritizing muscle and fat deposition, which may explain the insignificant differences observed in other carcass production parameters apart from breast meat and abdominal fat percentages.

The lack of significant differences in non-carcass weight parameters is likely due to these components having reached their maximum developmental stage at the time of observation. According to Alshamy *et al*. (2018) and Hidayat *et al*. (2020), the digestive organs of broilers develop rapidly during the first and second weeks of life, after which their growth particularly the relative weight of the intestines slows down, exerting minimal influence on final non-carcass weight. In addition, feathers are another component of non-carcass weight that are influenced by dietary protein content. Therefore, protein intake during the pre-starter and starter phases is partially allocated for feather development. By the finisher phase, feather growth is relatively complete, thus having little impact on non-carcass weight differences.

Another factor contributing to the lack of significant differences is that variations in protein intake due to different commercial feed types have a more pronounced effect on breast meat percentage and abdominal fat percentage, rather than on other carcass parameters. This is consistent with Juniarti *et al*. (2019), who stated that breast meat accounts for the largest portion of carcass weight due to its high muscle tissue content, which is influenced by dietary protein levels. Variations in protein content in the feed affect amino acid balance, which determines the quality of protein deposition in muscle. This aligns with findings from Pekel *et al*. (2020), who reported that broilers fed diets with high amino acid density exhibit increased muscle development, leading to higher breast meat percentages. Based on these findings, it can be concluded that commercial feed types cause variations in breast meat yield, even when live weight and carcass weight are similar.

The proportions of carcass and non-carcass components in this study were not significantly different (P>0.05) within the live weight range of 1469.33–1629.67 g. This finding is consistent with the results of Pratama *et al*. (2015), who reported that broilers with live weights ranging from 1.3 to 1.6 kg did not exhibit significant differences in carcass percentage. Similarly, Nggi and Bira (2018) found that non-carcass percentages generally do not differ significantly in broilers weighing less than 2 kg. In contrast, abdominal fat percentage showed a significant difference (P<0.05), likely due to the observation point being at 29 days of age, a period during which exponential fat deposition is still occurring. According to Jariyahatthakij *et al*. (2018), abdominal fat percentage reaches its optimal level at around 42 days of age, after which it tends to stabilize, resulting in no significant differences in fat deposition at that stage.

Broilers fed commercial diets A and D yielded higher GCP values compared to those fed diet B (Table 4). This outcome is attributed to the higher carcass weights observed in broilers receiving diets A and D, although statistically not significantly different (Table 2). According to Karpriana and Tribudi (2019) and Zulfan *et al*. (2020), higher carcass weight corresponds to greater carcass value. Additionally, the feed price during the rearing period also plays a crucial role in determining GCP, as each commercial feed contains different ingredients, leading to variations in cost per kilogram.

The GCP values were also consistent with the Income Over Feed Cost (IOFC), which was higher in broilers fed commercial diets A and D compared to those fed diet B (Table 5.). The GCP values for diets D and A were IDR 21,713.7 and IDR 20,652.3, respectively, while their corresponding IOFC values were IDR 18,958 and IDR 18,464. IOFC calculations were based on live body weight and live bird market price, whereas GCP was derived from carcass weight and carcass price per bird. As stated by Zulfan and Zulfikar (2020), IOFC reflects income above feed costs only and does not account for other expenses, such as operational costs incurred during broiler rearing.

Low feed prices do not necessarily reduce the overall feed cost during the rearing period. According to Zulfan *et al*. (2020), feed costs are primarily determined by the amount of feed consumed by broilers; therefore, even when feed prices are low, the quantity of feed intake must be taken into consideration. Based on the data in Table 4, the total feed cost for broilers fed commercial diets A, D, and E was significantly lower (P<0.05) than those fed diets B and C. Thus, when feed cost is considered as one of the key production cost components, commercial diets A and D offer a more economical option compared to diet B.

Whole carcass prices did not differ significantly (P>0.05), which is consistent with the absence of significant differences in live weight and carcass weight (Table 2). Generally, greater live weights yield higher carcass weights, which in turn increase carcass value. The average market price for broiler carcasses from June to December 2022, according to the SIMPONI-Ternak website, was IDR 33,985 per kilogram. Nggena *et al*. (2019) explained that carcass production, market price, live weight, and market demand for broiler carcasses all influence carcass pricing. Although statistically similar carcass weights yield similar carcass prices, commercial feeds A and D produced higher carcass prices than feed B. The average whole carcass prices resulting from feeds D, A, and B were IDR 38,742.9, IDR 38,017.9, and IDR 33,939.7, respectively.

Carcass grade did not differ significantly among broilers with similar carcass weights. Carcass grading is based on conformation, musculature, fat deposition, and the presence of defects in the broiler carcass. When rearing conditions are not extreme and body weights are relatively uniform, carcass grades tend to remain consistent. According to Abubakar (2003), factors influencing carcass grade include slaughter age, feed intake, nutrient composition, and live body weight. The study's comprehensive evaluation of commercial feeds across all feeding phases (pre-starter, starter, and finisher) and economic analysis presents a novel approach not commonly addressed in existing literature; however, further research is needed to ensure more detailed protein quality.

Conclusion

Commercial feed produced by company D, followed by company A, provided the best results in terms of broiler carcass performance, improved breast meat percentage, and GCP with less abdominal fat compared to other commercial feeds.

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Conflict of interest

The authors have no conflict of interest to declare.

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