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Carcass and Chemical Quality of IPB D1 Chicken Meat in Free-range and Intensive Systems

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ABSTRACT

IPB D1 chicken is a local chicken resulting from crossing *pelung*, *sentul, kampung*, and *parent stock* broiler *strain* Cobb chickens. IPB D1 chicken was released through a decree by the Ministry of Agriculture with No. 693/KPTS/PK. 230.M/9/2019. Free-range is a system of raising farm animals, including chickens, by providing access to outdoor running (pasture) to exercise, find more feed, and be exposed to more oxygen. This study analyzed the carcass percentage, edible carcass, non-edible carcass, and chemical quality of IPB D1 chickens raised in a free-range system. A total of 50 IPB D1 male chickens were raised in free-range and intensive systems for four weeks. The microclimatic data were analyzed descriptively. Meanwhile, carcass percentage and physicochemical and organoleptic properties of IPB D1 chicken meat were subjected to a *t*-test. Free-range and intensive systems showed no significant effects on the carcass, commercial cuts, edible and non-edible percentages, and MDA quality traits of IPB D1 male chicken thigh meat. The cholesterol content of IPB D1 thigh meat in a free-range system was significantly lower than in an intensive system

Keywords: carcass, free-range, IPB D1 chicken, cholesterol, MDA

INTRODUCTION

The poultry farming industry is a potential industry in Indonesia because the demand for poultry food continues to increase annually (Aedah *et al.* 2017). The broiler chicken industry still meets the need for chicken meat and eggs in Indonesia, where 90% of the production components, both seeds and feed, are imported (Sumantri and Darwati 2017). The local chicken industry is not well developed, mainly because of the lack of a local chicken breeding industry. Local Indonesian chickens have good adaptability and genetic diversity, which, if developed, will increase chicken productivity and meet chicken meat needs (Habib *et al.* 2020). One of the weaknesses of local chickens is their slow growth, resulting in several new strains formed by several researchers in Indonesia, including IPB D1 chickens, whose growth is faster (Nepa *et al.* 2023).

IPB D1 chicken is a local chicken that comes from the cross between *pelung, sentul, kampung*, and parent stock broiler strain Cobb and has been confirmed through a decree from the Ministry of Agriculture with No. 693/KPTS/PK.230.M/9/2019. IPB D1 chickens were formed to increase the productivity of local chickens by combining the advantages of each crossed chicken. IPB D1 chickens have good productivity, endurance, and adaptability to rearing conditions (Sumantri and Darwati 2017).

Chicken productivity is influenced by both genetic and environmental factors (Lukmanuddin et al. 2018). IPB D1 chickens had a genetic composition of broiler chicken breeds (25%) with three local chicken clusters (25% *pelung*, 25% *sentu*l, and 25% *kampung*). Chickens have the advantages of rapid growth and good disease resistance without reducing the taste, which is still acceptable to the community (Habib *et al*. 2020). In addition to genetic factors, chicken productivity is also influenced by environmental factors, including feed quality, microclimate, and management (Utama *et al*. 2021). The intensive raising system that has been applied has several shortcomings; poultry is uncomfortable, and it is difficult to control the temperature, especially in open-house cages (Susanti et al. 2016). An alternative to overcoming the weaknesses of the intensive system in open cages is a free-range raising system. Free-range is a poultry raising system that raises chickens in the pasture, providing feed so that the poultry are more comfortable and receive sufficient oxygen (Miao *et al*. 2005).

Fitra *et al.* (2021) demonstrated that 12-week-old free-range chickens of the *Indigofera zollingeriana* grass

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type produced meat with a cholesterol content of 43.77 mg 100 g^{-1}. Cholesterol in that study was lower than that reported by Sutama *et al.* (2010), who raised free-range chickens with an intensive system at 12 weeks of age using commercial feed-produced meat with a cholesterol level of 59.65 mg 100 g^{-1}. Hakim (2017) showed that the percentages *of* edible broiler chickens aged 40 days were 85.18 and 14.81%, respectively. The tenderness of chicken raised in the free-range system increased by 22.70 kg cm^{-2}, while intensive rearing was lower at 22.50 (Fitra *et al.* 2021). The results of laying hens (layers) and broiler chickens (broilers) in a free-range system with a grazing density of 10.00 ha^{-1} produce eggs containing higher protein and carotenoids, vitamins A and E, omega-3 and 6, and low cholesterol content. Meat quality is high in protein and low in fat (Fitra *et al.* 2021). Free-range rearing of IPB D1 chickens has never been carried out; therefore, this study aimed to examine the percentage of carcasses and physicochemical and organoleptic qualities of IPB D1 chicken meat kept in a free-range and intensively. The intensive raising system has shortcomings, such as stressed poultry, which will decrease health, productivity, and product quality. The free-range system is considered to apply the concept of animal welfare because it maintains poultry by raising chickens in the pasture, feeding them, getting sunlight, and getting enough oxygen so that the poultry is in good welfare. IPB D1 chickens are local chickens derived from a cross between male F1 PS (*pelung* × *sentul*) and female F1 KM (*kampung* × parent stock broiler strain Cobb), which have the advantage of good adaptability to different maintenance conditions, resistance to diseases, and rapid growth. IPB D1 chickens were the result of crosses with free-range chickens. One of the advantages of IPB D1 chickens is that they can utilize local feed, such as free-range chickens. Therefore, it is necessary to research whether free-range and intensive maintenance systems affect the percentage of carcasses and the physicochemical and organoleptic qualities of IPB D1 chicken meat.

METHODS

Study Time and Site

This study was conducted from December 2022 to February 2023. Chicken rearing was performed at the Laboratory of the Jonggol Animal Husbandry Education and Research Unit. The physical and organoleptic qualities of the meat were tested at the IPB Product Technology Laboratory. Meat MDA analysis was conducted at the IPB Integrated Laboratory, and meat cholesterol analysis at the Saraswanti Indo Genetech Laboratory Bogor.

Equipment and Materials

The facilities were two open house-type cages measuring 2 × 3 m^2, equipped with drinking places, feed places, temperatures, and lights. Other means used for rearing were digital scales, RHT10 dataloggers, pH meters, footrings for chicken numbering, cooling boxes, and organoleptic test form paper.

The material used was 50 IPB D1 roosters that were 8 weeks old. The materials used in physicochemical and organoleptic analyses included thigh meat, phosphate buffer, BPS solution, KCl, concentrated HCl, trichloroacetic acid, thiobarbituric acid, H_2O, distilled water, and supernatant solutions.

Free-Range Preparation

The pasture was 12 × 12 m^2 and planted with *odot* grass (*Pennisetum purpureum* cv. Mott), and there were types of *peking* grass and field grass. A mesh fence surrounded the area to keep chickens from leaving and prevent predators from entering the area. The breeding area used refers to the free-range rearing system in Australia, which has a density of one chicken per 10 m^2 (maximum 10,000 ha^{-1}) (McCormack 2017).

Cage Preparation

The cages were 2 × 3 m^2 for the free-range and intensive raising systems. Each cage was filled with 25 IPB D1 roosters. The cage had a feed place, drinking place, lights, and wood for perching.

Feed Preparation

The feed was prepared as needed for the growth period of the chickens (Leeson and Summer 2005). Feed formulation with nutritional content: metabolic energy 3005.90 kcal kg^{-1}, crude protein 18.06%, fat 5.49% and crude fiber 3.35%. Feed was provided in the morning and evening as the main feed for the fulfillment of nutrients in the chickens. The additional feed used was *odot* grass forage planted in the pasture area, which chickens will later consume from noon to evening. The nutrient content of the *odot* grass included metabolic energy (4816 kcal kg^{-1}), crude protein (15.80%), crude fat (3.20%), and crude fiber (31.50% (Lestari *et al.* 2022). *Odot* grass was administered to the chickens at 10–20% of the total feed (Table 1).

Raising

The chickens were maintained at the age of 8-12 weeks. Each cage was filled with 25 IPB D1 roosters. Feed was provided according to age, and drinking water was provided *ad libitum*. In the intensive rearing system, chickens were in the coop all day. Chickens in the free-range chicken system were given access to the chicken coop from 08.00 to 17.00. Chickens in the pasture could receive additional feed in the form of forage planted on

Table 1 Feed composition and nutrient content

Feed composition	%
Corn	15.30
Rice bran	15.30
Soybean meal	18.00
Fish meal	8.00
Palm oil	2.00
$CaCO_3$	1.00
NaCl	0.20
Premix	0.50
Total	100
Nutrient content (calculation result):	
Crude protein (%)	18.06
Fat (%)	5.49
Course fiber (%)	3.35
Lysine (%)	1.19
Methionine (%)	0.43
Methionine + Cystine (%)	0.73
Ca (%)	0.95
P-available (%)	0.55
Na (%)	0.16
Cl (%)	0.23
EM (kcal/kg)	3005.90

Source: Leeson and Summer (2005).

land and consumed by poultry from morning to evening. Each chicken was marked with a leg number to make the recording easier. Temperature and humidity measurements were carried out three times a day, namel y at 08.00, 12.00 and 17.00. At the end of the maintenance period at the age of 12 weeks, the final body weight was measured. Furthermore, the chickens were cut to become carcasses, and parts of the carcass were slaughtered following the halal slaughter method for poultry (Directorate General of Livestock and Animal Health, Ministry of Agriculture of the Republic of Indonesia 2010). The physicochemical and organoleptic qualities of the thigh carcasses were tested. Five treatments were taken 5 chickens as samples.

Slaughtering

Chickens were slaughtered according to the DPKH method (2010). The chickens were fasted, but drinking water remained available for 6–8 h to guarantee they did not dehydrate. Fasting aims to empty the contents of the digestive tract so that contamination of the digestive tract content can be avoided when slaughtering chicken carcasses. Before slaughter, the chickens were weighed to determine the weight of the cuts. The chicken legs were tied with a rope and hung with the head facing downward for no more than 2 min. Chickens were slaughtered using the halal method. Slaughter was carried out by cutting the chicken by reading the *basmallah* and then cutting the feeding and respiratory tracts and two veins, namely the right and left blood vessels (BSN, 2016). The chicken was hung for 3-5 min until the blood stopped flowing or until the chicken was no longer moving and no blood was coming out. The chickens were dipped in hot water at 50-60 °C for 3 min or until feathers were easily removed. After the hair was removed, the viscera and abdominal fat were removed, and the head, neck, and legs were cut.

Parting and Deboning

Chickens were cut into carcasses using the Card and Neshem method (1972). The commercial carcass pieces were divided into quarters, including the right thigh, left thigh, right breast, and left breast. The breast was fused with the wings, and the thigh consisted of the upper and lower thighs. The carcasses that became commercial pieces were then deboned by separating the meat, bones, and skin from each piece.

Observed Parameters

- **Environmental Conditions**

Observation of environmental conditions was carried out for 30 days with data collection time three times a day, namely, in the morning at 08.00, at noon, and in the evening at 17.00. The variables of the observed maintenance environment conditions were the ambient temperature, air humidity, and temperature humidity

index (THI). Ambient temperature and air humidity were measured using an RHT 10 datalogger. The RHT10 was positioned in two locations: on the outside of the cage and inside the cage (in the intensive cage and free-range cage, respectively) to measure the temperature and humidity. The calculation used the formula proposed by Tao and Xin (2003).

$$THI = 0.85\ T_{db} + 0.15\ T_{wb}$$

where
THI = Temperature Humidity Index, ^oC
T_{db} = Dry-bulb Temperature, ^oC
T_{wb} = Wet-bulb Temperature, ^oC

- **Characteristics of Carcass**

All aspects of IPB D1 chicken production were recorded during the experiment.

a. Final body weight (g/head) was measured at the end of the rearing period before slaughter. The chickens were weighed and fasted for 8 h.
b. Carcass weight (g/head), body weight after deducting the head, blood, internal organs, legs, abdominal fat, neck, feathers, and skin (g/head).
c. The percentage of carcass (%) was obtained by dividing the weight of the carcass by the live weight multiplied by 100%.
d. The commercial carcass cut (g/head) weight was calculated from the breast and thigh weights (g/head).
e. The commercial percentage of the breast and thigh (%) was calculated from the weight of each breast and thigh divided by the weight of the carcass multiplied by 100%.
f. The percentage of edible carcasses (%) was calculated as the edible carcasses (g/head) divided by the weight of the carcass (g/head) multiplied by 100%.
g. The percentage of non-edible carcasses (%) was calculated as the weight of non-edible carcasses (g/head) divided by the weight of the carcass (g/head) multiplied by 100.

Observation of Chemical Quality of IPB D1 Chicken Meat

- **MDA (Malondialdehyde)**

The preparation and measurement of meat samples were carried out following the method described by Jo and Ahn (1998), with several modifications. Chicken meat homogenate for MDA analysis was made by ± 1 g of ground beef composite under cold conditions, then added with 2 mL of BPS solution (1.15 g KCL in 100 mL PBS) pH 7.4 in homogenization. The resulting homogenate was centrifuged at 10,000 rpm for 20 minutes. The supernatant was collected and immediately stored at –20 °C. MDA was used as the standard solution. The MDA standard solution was prepared by diluting the working solution to obtain standard concentrations of 0, 0,5, 1, 2, 3, 4, 5, 10, 20, 40, and 80 µmol L^{-1}. A total of 1 mL of meat homogenate was added with a mixed solution (2.2 mL of concentrated HCL + 10 g of trichloroacetic acid [TCA] + 0.38 g of thiobarbituric acid [TBA] + 100 mL of H_2O). The mixture was heated at 80 °C for 1 h. After cooling, the solution and standard centrifuge gas were mixed at a speed of 2500 rpm for 5 min. The supernatants were separated, and their absorption was measured at a wavelength of 532 nm with a spectrophotometer. A standard curve was constructed by plotting the absorbance value (y-axis) against the concentration of MDA (x-axis) and obtaining the MDA value (µmol L^{-1}), which was converted to µg g^{-1} of the sample.

$$T_{BARS} = \frac{Cmda\ x\ Vdes}{Ms}$$

where:
C_{mda} = MDA concentration that reads on standard curves
Ms = Sample weight
V_{des} = Distillate volume

- **Meat cholesterol level**

Colorimetric Cholesterol Level Analysis (Sahriawati *et al.* 2016). First, the Liebermann-Burchard reagent solution was used. Anhydrous acetic acid was cooled for 30 min, and then concentrated sulfuric acid was added at a ratio of 10:1. The reagents were freshly prepared. Second, there are standard solutions. A total of 10 mg of standard cholesterol powder was weighed and placed into a 10 ml measuring flask. Then, it was dissolved with chloroform to the limit mark to obtain a standard cholesterol solution (1000 ppm), which was used as a standard stock solution.

Determination of the maximum wavelength of cholesterol using the Liebermann-Burchard reagent. A total of 0.375 mL of standard 1000 ppm plus 2 mL of Liebermann-Burchard reagent in a 5 mL flask was rounded to the limit mark with chloroform. The mixture was incubated for 5 min. The absorbance was measured in the 400-700 nm wavelength range using a visible spectrophotometer and three replicates.

Determination of the color stability time between cholesterol and Liebermann-Burchard reagents. A total of 0.375 mL of standard 1000 ppm plus 2 mL of Liebermann-Burchard reagent in a 5 mL flask was rounded to the limit mark with chloroform. Absorbance was measured at a maximum wavelength every 5 min

for 60 minutes and performed thrice.

Validation. Determination of linearity. A total of 0.075, 0.150, 0.225, 0.300, and 0.375 mL of standard 1000 ppm solution, each plus 2 mL of Liebermann-Burchard reagent in a 5 mL flask, was rounded to the limit mark with chloroform. The mixture was incubated for 5 min. Absorbance was measured at the maximum wavelength. Each concentration was measured three times, and then a linear equation was derived using the linear regression method ($y = ax + b$). The linearity of the calibration curve can be seen from the value of the correlation coefficient (r) (Gandjar and Rohman 2013).

Determination of cholesterol levels by external methods. A total of 50 mg of broiler chicken meat extract from each thigh and breast part was placed in a 25 mL flask and dissolved with chloroform to the limit mark. A total of 1 mL of sample solution plus 2 mL of Liebermann-Burchard reagent in a 5 mL flask was rounded up to the limit mark with chloroform. Each mixture was then incubated for 5 min. Absorbance was measured at the maximum wavelength, and the solution was prepared three times. The cholesterol levels were calculated using the following formula:

$$\text{Cholesterol content (mg\%)} = \frac{\text{Absorbance}_{sample}}{\text{Absorbance}_{standard}} \times \frac{\text{Concentration}_{standard}}{\text{Weight}_{sample}} \times 100\%$$

Data Analysis

As a treatment in this study, it was a free-range and intensive maintenance system for IPB D1 roosters during the growth period. Each treatment consisted of 25 chickens; each parameter tested was obtained from five chickens. The observed data included microclimatically tested descriptively, percentage of carcass, percentage of thigh weight, percentage of breast weight, percentage of edible weight (meat and skin), percentage of non-edible weight *(*bone), pH, aw, cooking loss, tenderness, MDA, cholesterol, and hedonic quality. The data were tested using t-tests (Matjik and Sumertajaya 2013).

$$t_h = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)S_{12}+(n_2-1)S_{22}}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

where

t_h = T value calculated
$\bar{x}_1$ = Average value of chickens with intensive system
$\bar{x}_2$ = Average value of chickens with free-range system
n_1 = Number of chicken samples with intensive system
n_2 = Number of chicken samples with free-range system
S_1^2 = Standard deviation with intensive system
S_2^2 = Standard deviation with free-range system

RESULTS AND DISCUSSION

Rearing Environment Temperature

The environmental temperatures of IPB D1 chickens in free-range and intensive system maintenance are presented in Table 2. The temperature in free-range and intensive systems was 23–35°C. The optimum temperature for raising free-range chickens during growth is 18–25°C (Gunawan and Sihombing 2004). High temperatures are caused by extreme weather, resulting in high solar radiation (Syaefullah *et al.* 2021). Chickens in intensive system maintenance of chickens carry out a metabolic process limited to a limited room with a density of 4 m^2. The result of metabolism is carbon dioxide and water vapor, which cause the temperature in the cage to be high. This is following the opinion of Sulistyoningsih (2003), who stated that the environment and heat discharge from the chicken body influence the temperature in a cage.

The humidity range used in this study was 56–96%. The comfortable humidity for chickens is 50-60%

Table 2 Environmental conditions during the study

Parameter	Free-range	Intensive
Temperature (ºC)		
Morning (08.00) WIB	30–32	30–32
Noon (12.00) WIB	30–35	30–35
Evening (17.00) WIB	23–28	23–31
Humidity (%)		
Morning (08.00) WIB	66–78	68–93
Noon (12.00) WIB	56–77	57–96
Evening (17.00) WIB	70–97	68–94
Temperature humidity index		
Morning (08.00) WIB	27.9	28.7
Noon (12.00) WIB	31.3	32.0
Evening (17.00) WIB	28.9	29.8

(Sulistyoningsih 2003). High humidity indicates that the air in the cage contains high moisture content (Putra *et al.* 2018). The temperature humidity index (THI) combines ambient temperature and relative humidity and assesses stress levels in poultry. The THI range in poultry is normal (< 27.8; medium 27.8–28.8; severe 28.9–29.9 and very severe ≥ 30.0 (Hahn *et al.* 2009). The morning THI range was included in the moderate category of free range and intensive maintenance. THI during the day is included in the very severe category, and that in the evening is included in the severe category. Based on the THI score, the research location in Jonggol in the evening and during the day generally does not support chicken rearing; however, IPB D1 chickens that are raised in free-range and intensive conditions can live well. This is because IPB D1 chickens have 75% local chicken blood that has adapted well to environmental conditions in Indonesia (Sumantri and Darwati 2017).

Carcass Percentage and Parts

The percentage of carcass weight of IPB D1 roosters aged 12 weeks, kept in a free-range and intensive manner, was not significantly different (Table 3). This is because genetic factors, age, feed consumption, feed nutrient content in protein, and energy are relatively the same, with the same maintenance temperature. Almost the same feed consumption affected the growth rate, which was not different. The level of feed consumption affects growth rate because the weight and body composition are the accumulation of feed consumed by livestock (Setiadi *et al.* 2011). In addition to feed consumption, the nutrients in the main feed in this study are the same, which contain 18.06% protein and feed energy of 3005.90 kcal/kg. According to Nuraeni *et al.* (2018), the percentage of chicken carcasses is influenced by genetic factors, such as sex, feed consumption, feed nutrients, protein intake, and environment. The energy and protein contained in the feed are used to produce meat in the body (Dita *et al.* 2021). Protein and energy content are related to the percentage of carcasses (Anggitasari *et al.* 2016).

The percentage of carcasses in this study was higher than that of 12-week-old male sentul chicken carcasses in an intensive system with commercial feed, ranging from 53.04% (Indra *et al.* 2015). The percentage of carcasses produced in this study ranged from 57.87 to 58.09% of the cut weight. The percentage of carcasses in this study was lower than that reported by Fitra *et al.* (2021), who reported a live weight of 821 g/head with a carcass percentage of 62.00% in 12-week-old free-range leguminous *Indigofera zollingeriana plants*. The study by Nadia *et al.* (2023) using intensively raised 35-day-old broiler chickens exposed a higher percentage of carcasses (70.05%).

Thigh and breast weight percentages did not differ significantly between the groups. The main feed contained the same nutrients, especially protein, energy, and minerals. The content of food substances, such as protein, energy, and minerals, is used to form components of commercial cuts, such as meat and bones (Nita *et al.*2015). According to Dwiky *et al.* (2017), there is a close relationship between the weight of the carcass and the parts of the carcass; therefore, if the results of the carcass weight analysis are not significantly different, the results are not significantly different in the commercial parts of the carcass.

The commercial pieces with the highest percentage in this study were breasts in the free-range system (50.67%) and the intensive system (50.63%). The percentage of thighs in the free-range system was 49.33% and 49.37%, respectively. A high percentage of breast tissue is affected by muscle tissue. Muscle growth is influenced by proteins, particularly amino acids (Noviyanti *et al.* 2023). In addition, the breast is not included in the movement apparatus; therefore, its energy is higher and will be deposited into meat and fat (Genchev and Mihaylov 2008).

The results of this study are higher than those reported by Fitra *et al.* (2021), who showed a breast percentage of 47.70% and a thigh percentage of 41.40% in 12-week-old free-range chickens with the legume *I. zollingeriana*. Hendratono's (2019) study showed that the average slaughter weight of IPB D1 roosters aged 12 weeks in intensive system maintenance resulted in a slaughter weight of 931 g/head, carcass percentage of 61.19%, thigh percentage of 29.15%, and breast percentage of 34.65%. Research by Nadia *et al.* (2023) using intensively raised 35-day-old broiler chickens resulted in a breast weight percentage of 58.88% and a thigh weight of 41.01%.

Percentage of Edible and Non-Edible Carcasses

Edible *carcasses are* the edible parts of the carcass, including meat, fat, and skin. Non-edible carcasses are

Table 3 Slaughter weight, carcass weight percentage, thigh weight percentage and IPB-D1 chicken breast weight percentage in free-range and intensive system

Parameter	Free-range	Intensive
Whole carcass (%)	58.09 ± 3.04	57.87 ± 9.54
Carcass section		
Tigh (%)	49.33± 1.70	49.37 ±6.92
Breast (%)	50.67 ± 1.70	50.63 ± 6.92

inedible carcasses that consist of bones (Ulupi *et al.* 2018). Table 4 displays that the total percentages of *edible* carcasses (meat and skin) were not significantly different. This is because the feed nutrients used in this study were the same. The results of this study are higher than those reported by Royani *et al.* (2021), with 35.68% edible carcasses in 12-week-old Sentul chickens. Based on the results of a study by Ulupi *et al.* (2018), edible carcasses in 30-day-old male broiler chickens were higher than the percentage of *edible* carcasses in chickens in the present study, namely, the percentage of edible meat 68.03% and skin (14.70%).

Proteins are the main components in meat formation (Kim *et al.* 2007). In this study, the average percentages of edible carcasses (meat) in the free-range and intensive systems were 58.93% and 61.95 %, respectively. There was no significant difference based on the statistical test of *the percentage of edible* meat in this study. This is because the main feed nutrient content in this study was the same: a protein content of 18.06% with the same protein intake. Proteins play an important role in the growth of meat muscles, so a ratio with almost the same protein content will produce a meat weight that is not much different (Antari *et al.* 2020). Observations on feed consumption in the free-range system was 60.02 g/head day-1 and in the intensive system of 59.03/heads day^{-1}. The total protein intake in both treatments was 10.84 g/head day^{-1} for the free-range system and 10.66 g/head day^{-1} for the intensive system. This shows that IPB D1 chickens obtained almost the same total protein intake; therefore, the percentage of edible carcasses (meat) produced from the two treatments was not different. According to Suryanah *et al.* (2016), factors that affect the percentage of edible carcasses (meat) are feed consumption and handling during the separation of meat and bones. The results of this study are higher than those of Tasse *et al.* (2021) by 52.97% in 8-week-old super-free-range chickens. The percentage of broiler chicken meat aged 35 days ranged from 42.40–50.10% (Pratama *et al.* 2015).

The skin in poultry has several functions, namely, protecting the body from the entry of substances, regulating body temperature, and acting as a secretory gland (Rakhmawati and Sulistyaningsih 2019). Statistical tests showed no significant difference in the percentage of IPB D1 chicken bones in the maintenance of the free-range system (4.27%) and intensive system (6.40%). According to a study by Tasse *et al.* (2021) Factors that affect skin percentage include skin weight, genetics, sex, and environment. The results of this study are lower than those of Tasse *et al.* (2021) by 7.26% in super-free-range chickens aged 8 weeks. Meanwhile, the percentage of broiler chicken skin weight aged 35 days fed *katuk* leaf flour was approximately 8.55% (Nathanael *et al.* 2015).

Non-edible carcasses *(*bones) comprise calcium components (Patriani 2019). Calcium levels are closely related to bone formation. Bone growth is influenced by genetics, feed, growth rate, and environment (Samsudin *et al.* 2012). The percentages of non-edible carcasses in the free-range and intensive system maintenance groups did not differ significantly, namely 41.07 and 38.05%, respectively. The *t*-test results show that the average of the two treatments were not significantly different. This was because the nutrient content of the feed was arranged, especially with the same calcium content. Based on calculations, the calcium intake in IPB D1 chickens in the free-range system was 0.57 g/head day^{-1} and 0.56 g/head day^{-1} in the intensive system, according to the study by Adnan *et al.* (2016). The calcium intake of local chickens in the growth phase is 0.54–0.60 g/head day^{-1}. The calculation results showed that the calcium intake in the two treatments was almost the same according to the standard needs of chickens during the growth period. Almost the same calcium and protein intake led to no difference in bone growth (Kurniawan *et al.* 2012). The results of this study were higher than those of Patriani (2019) in 35-day-old broiler chickens that were intensively raised, resulting in a bone weight percentage of 22.49%. According to a study by Tasse *et al.* (2021), the bones in super free-range chickens aged 8 weeks was approximately 36.23%.

Chemical Quality of IPB-D1 Chicken Meat

The chemical properties of IPB D1 chicken meat, namely MDA (malondialdehyde) and cholesterol, are presented in Table 5. Age, sex, feed, and ambient temperature can also affect the characteristics of chicken meat (Rini *et al.* 2019). The statistical analysis results showed that physical quality and MDA levels were not significantly different (P>0.05). This is because of the same genetics, age, feed, and maintenance temperature.

Table 4 Percentage *of* edible carcass (meat and skin) and percentage of non-edible carcass IPB-D1 chickens in free-range ar intensive system rearing

Parameter	Free-range	Intensive
Edible (%)	58.93 ±3.44	61.95 ± 8.44
Meat (%)	54.66 ± 3.89	55.55 ± 8.67
Skin (%)	4.27 ± 1.48	6.40 ± 2.77
Non-edible bone (%)	41.07 ± 3.44	38.05 ± 8.44

Heat stress is a heat imbalance between a livestock's body and its environment (Mushawwir 2019). Temperature and humidity above the comfort zone of chickens trigger an increase in oxidative stress that causes free radical attacks on cell membranes. MDA is a product of lipid peroxidation and is an indicator of oxidative stress and cell membrane damage in the body (Arkhaesi 2008). The results of the statistical tests in IPB D1 chickens with free-range and intensive system rearing in this study were not significantly different. This is due to the same temperature of the maintenance environment, such that the average value of MDA in this study is almost the same. The MDA value of this study was lower than the results of Wicaksono *et al.* (2016), which stated that the MDA content in the meat of broiler chicken thighs that were intensively raised with a THI of 27.78 was 0.40 µmol g^{-1} (Wicaksono *et al.* 2016).

The cholesterol level of chicken thighs in the free-range system preservation was significantly lower than that in the intensive system. This is due to the maintenance of the free-range system in the overgrown grass and consumption by chickens, which is characterized by a reduction in grass in the free-range area, as depicted in Figure 1. *Odot* grass contains 31.50% crude fiber. The coarse fiber in the chicken digestive tract binds most of the bile salts to be excreted through the excreta. Since most bile salts are excreted, the body needs to synthesize bile salts derived from cholesterol to reduce cholesterol (Manafe 2022). Odot grass contains flavonoids that act as synthetic cholesterol inhibitors. Flavonoids lower cholesterol levels in the blood by inhibiting the action of the HMG Co-A reductase enzyme (Ranti *et al.* 2013). In addition to containing flavonoid compounds, odot grass contains saponins that reduce cholesterol absorption levels and increase cholesterol excretion to reduce meat cholesterol in IPB D1 chickens. Physical activities such as walking and foraging can increase calorie burning in chickens by reducing excess body fat. Physical activity in chickens can contribute to reducing chicken meat fat and cholesterol (Davoodi and Ehsani 2020). The cholesterol level in this study was lower than the results of Saidin's (2000) study of 116 mg 100 g1 in 12-week-old intensively raised free-range chickens. Suharti *et al.* (2010) showed that the cholesterol level in the thighs of broiler chickens aged 35 days was more by 125.75 mg 100 g-1.

CONCLUSION

IPB D1 chickens raised in a free-range and intensive system produced a percentage of carcasses, carcass parts, edible, non-edible, and malondialdehyde (MDA) carcasses that were not different. Cholesterol levels in free-range system preservation were lower (69.57 mg 100 g^{-1}) than in intensive system preservation (88.61 mg 100 g^{-1}).

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Table 5 Physicochemical quality of IPB-D1 chicken thigh meat that were raised free-range and intensively

Parameter	Free-range	Intensive
MDA (µmol g^{-1})	0.20 ± 0.02	0.22 ± 0.01
Cholesterol (mg 100 g^{1})	69.57 ± 2.60^{a}	88.61 ± 7.75^{b}

Remark: Different superscripts on the same line show significant differences.

Figure 1 *Odot* grass before consumption (a) and after consumption by the poultry (b).

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