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THE INFLUENCE OF OPEN, SEMI-CLOSED, AND CLOSED HOUSE MICROCLIMATES ON BROILER PRODUCTIVITY IN THE DRY SEASON

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ABSTRACT

In Indonesia, there are three housing systems: sometimes open, semi-closed and closed. This study aimed to analyze the effect of microclimatic conditions, NH_3, and *E. coli* levels on broiler productivity in open, semi-closed, and closed houses during the dry season. The research took place in June - August 2019, when the air temperature was 28°-34°C during the day, while at night, the air temperature was around 21°-25°C with rainfall < 60 mm/month. The material used was the Lohmann strain broiler. Observations were made in six house units consisting of two open house units with a total of 5,000 chickens/house unit, two semi-closed units with a total of 18,000 chickens/house unit, and two closed house units with a total of 33,000 chickens/house unit. This research is survey research, with the experimental parameters being temperature (^oC), humidity (%), wind speed (m/s), NH_3 (ppm) and *E. coli* (CFU/mL), body weight (g/bird), FI (g/bird/day), FCR, IP, mortality, and IOFC. Based on the study's results in open, semi-closed, and closed houses, there were differences ($P<0.05$) in temperature, humidity, wind speed, and NH_3, whereas in *E. coli* they were not significantly different. In broiler productivity, the type of house affected body weight ($P<0.05$), while on FI, FCR, IP, mortality, and IOFC were not significantly different ($P<0.05$). The conclusion is that the range of temperature, humidity, and wind speed in all houses is still in the standard range of broiler maintenance. NH_3 and *E. coli* levels were below the threshold that chickens could tolerate, although the highest levels were in closed houses. This affects the BW of broilers in open and semi-closed at weeks 1, 2, and 3, which is higher than in closed houses.

Keywords: microclimate, NH_3, and *E. coli*, chicken productivity

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INTRODUCTION

Improving the genetic quality of broilers must be balanced by good management or management in order to produce optimal production. Maintenance management, including maintenance and housing management, is a fundamental matter that directly influences the success of the livestock business. Houses are an important part of maintenance management because they are the place for all livestock activities, so livestock comfort must be guaranteed to obtain healthy and productive livestock. If reared in unfavorable environmental conditions, livestock cannot perform according to their genetic potential, which means economic losses (Feddes et al., 2002). Providing comfortable housing for broilers is one of the most important and fundamental problems in poultry production.

Commercial production of broiler chickens requires the construction of house with appropriate and adequate designs and facilities to achieve optimal productivity. The broiler production system is inseparable from microclimatic conditions, namely ventilation, lighting, temperature, humidity, and liter management (Soliman, Moawed, and Hassan, 2017). Differences in microclimatic conditions in each house will affect broiler performance, including body weight, consumption and FCR (Czarick & Fairchild, 2012), performance index, mortality, and IOFC (income over fixed cost). In addition to the house microclimate, the level of NH_3 and *E. coli* in litter also greatly influences the productivity of broilers.

There are three housing systems: open house systems, semi-closed, and closed. Open houses are houses whose walls are made with an open system, usually made of bird wire or bamboo, ensuring that wind can enter the house and take advantage of changing sunlight. The walls of the house are covered with curtains that function as ventilation. In a closed house system, the microclimate in the house can be adjusted as needed. In open houses, the microelements in the house depend on the natural conditions around the house environment. Closed model houses are intended to minimize contact between chickens and fluctuating environmental conditions outside the house (Unang, et al. 2012). Closed-type houses have closed walls and are usually made of permanent materials with a high-tech touch. This house uses an exhaust fan that functions to attract or suck up oxygen and emit carbon dioxide and uses a cooling pad system Priyono (2009).

The closed house system has many advantages over the open house. The advantages such as the situation of temperature and humidity in the house can be adjusted so that changes in temperature and humidity are minimized, the density of the house is higher (12–14 individuals/m2) compared to open houses (8–10 individuals/m2) (Purnomo & Santosa, 2007). The Performance Index (IP) of broiler farms in open houses is around 340-360, while rearing in closed houses can reach 400 (Unang et al., 2012). Maintenance in closed houses has a difference in chicken weight compared to open houses, namely at the age of 1-7 days has a difference of 20.05%, at the age of 8-14 days has a difference of 18.08%, at the age of 15-21 days the difference is 14.42%, then the age of 22-28 days has a difference of 26.48% and at the age of 29-35 days has a difference of 23.24% (Prihandanu et al., 2015). However, so far, the reconstruction of open houses into closed houses or the construction of closed houses is faced with capital constraints owned by breeders, which are still far from sufficient for their development. In addition, other obstacles breeders face are the lack of technology and infrastructure, so currently, many semi-closed type houses are known, which are modifications of the open and closed house systems.

Seasons are division time in a year determined by changes in weather, ecology, and the duration of the sun's rays. Countries close to the equator have two seasons, namely dry and rainy seasons (Adrian,

Harmini, Budiman, 2011). The dry season generally lasts from around May-October. This season, the air temperature tends to be quite hot, around 28°-34°C during the day. At night, the air temperature will drop to around 21°-25°C. Rain also rarely occurs this season, so the Indonesian mainland generally experiences drought (BMKG, 2022).

This study aimed to analyze the effect of microclimatic conditions, NH3, and E.coli levels on broiler productivity, including body weight, feed consumption, FCR, performance index, mortality, and IOFC in open, semi-closed, and semi-closed houses.

MATERIALS AND METHODS

Location

The research was conducted at Company Farm PT. Ciomas Adisatwa in June - August 2019. For open houses located in Kenongo village, Jabung District, Malang Regency. The semi-closed house is located in Ganting Village, Maron District, Probolinggo Regency. The closed house is located in Kasri Village, Bululawang District, Malang Regency.

Research material

This research is survey research. The research material was a broiler Lohmann strain. Observations were made in six units of houses, which consisted of two units of open houses, two units of semi-closed houses, and two units of closed houses.

Open houses are houses where 100% ventilation comes from a curtain system on the walls and roof of the house. The house is made of wood and bamboo, with an asbestos roof. The floor on the 1st floor is dirt, while on the 2nd floor is bamboo covered with tarpaulin. The open house's specifications are the house's size 40 x 8 x 4 m (p x w x t). The number of broilers in open houses is 5,000 birds/per house unit.

Semi-closed houses are houses that are equipped with fans to regulate air circulation. The specifications for a semi-closed house are the size of the house 78 x 8 x 4 m (p x w x t). The walls are made of red masonry, chicken wire, and corrugated asbestos roof, the floor on the 1st floor is in the form of floor rebates, while the 2nd floor is covered with tarpaulin. Fan totaling ten units/floor. The number of broilers in semi-closed houses is 18,000 birds/house unit.

Closed houses are houses with tunnel-type ventilation equipped with an evaporative cooling pad and exhaust fan by utilizing a negative pressure system. The specifications for a closed house are the size of the house 120 x 12 x 4 m (p x w x t). Each house is a 2-story house with a gable roof type. The walls are made of red masonry, chicken wire, and corrugated asbestos roof, the floor on the 1st floor is in the form of floor rebates, while the 2nd floor is covered with tarpaulin. The litter material used is a husk with a thickness of 10 cm. The number of broilers in closed housing is 33,000 birds/house unit.

Observation

Data on temperature (^{o}C) and humidity (RH %) were taken four times a day at 06.00, 12.00, 18.00, and 24.00 WIB for 28 days. Using the thermo-hygro USB Temperature and Humidity Data Logger Model No. DS102. Wind speed is observed weekly using Kestrel 3000 weather meter part #0830. NH3 is measured weekly by placing an NH_3 detector brand Smart sensor AR 8500 (0-100ppm) on the litter. The litter samples used for the *E. coli* test were taken randomly from the house. The MPN test was carried out at the Laboratory of Plant Pests and Diseases, Faculty of Agriculture, University of Brawijaya, with a total sample of 24 units. Observation of *E. coli* litter at weeks 2 and 4.

The parameter of the study was the broiler performance, including body weight (BW), feed intake (FI), feed conversion ratio (FCR), index of performance (IP), and mortality.

1. The broiler's body weight (g) is weighed on the first day when the DOC comes in on the 7th, 14th, 21st, and 28th days. The sample was derived from 1% out of the whole population and taken randomly.

2. Feed intake (g/chicken) is the difference between the remaining ration and the total rations given. The remaining feed is weighed every week.
3. The feed conversion ratio is counted by dividing ration consumption and weight gain.

$$FCR = \frac{feed\ intake\ (g)}{weight\ gain\ (g)}$$

4. Index of performance

$$IP = \frac{[100 - dead\ chicken(100)]x\ average\ weight\ (kg)}{harvest\ time\ (day) x\ feed\ conversion}\ x\ 100$$

5. Mortality is the number of dead chickens recorded every day and then counted in percent. Mortality of the poultry is recorded every day.

Data analysis

Data on temperature, humidity, wind speed, NH_3 and *E. coli*, BW, FI, FCR, IP, mortality, and IOFC were analyzed by analysis of variance (ANOVA). If there was a difference, it was continued with the least significant difference test.

RESULTS AND DISCUSSION

House environmental conditions

Temperature

The microclimate of the stable will greatly affect the physiological conditions and productivity of livestock. A house with a temperature suitable for the thermoneutral zone of livestock will positively impact broilers' productivity. Therefore the house is made according to the needs of the livestock.

Table 1 shows that the type of house has a significant effect (P<0.05) on the temperature inside the house. In the first and second weeks, the temperature in the open pen was below the standard comfort zone for livestock, while in the closed and semi-closed pens, it was by the standard. This was allegedly caused by the low ambient temperature of the house at that time. The ambient temperature will greatly affect the temperature inside the house for the open house type.

Table 1. Microclimate of houses in open, semi-closed and closed houses

Week	Open House	Semi Closed house	Closed House
Temperature (°C)			
1	27.49 ± 2.53[a]	31.17 ± 2.59[b]	32.31 ± 0.83[c]
2	24.58 ± 2.96[a]	29.99 ± 2.96[c]	29.59 ± 0.88[b]
3	23.50 ± 3.59[a]	28.50 ± 2.96[c]	28.37 ± 1.19[b]
4	22.32 ± 4.16[a]	22.81 ± 2.37[b]	27.17 ± 1.42[c]
Humidity (%)			
1	58.02 ± 7.03[a]	66.68 ± 9.49[b]	61.84 ± 4.68[a]
2	66.65 ± 7.76[a]	68.91 ± 9.69[a]	67.69 ± 2.87[a]
3	66.84 ± 9.39[b]	66.50 ± 8.73[a]	72.98 ± 3.32[c]
4	66.69 ± 10.45[a]	73.69 ± 9.62[b]	74.21 ± 4.09[c]
Wind velocity (m/s)			
2	0.47 ± 0.08[a]	0.56 ± 0.14[a]	0.60 ± 0.67[a]
3	0.53 ± 0.13[a]	0.65 ± 0.17[a]	0.71 ± 0.80[b]
4	0.57 ± 0.08[a]	0.71 ± 0.18[a]	1.06 ± 1.31[b]

Note: different superscripts on the same line indicate a significant difference (p<0.05)

It also shows the lack of control of the child's house over the heater. Vucemilo, Matkovic, Vinkovic, Macan, Varnai, Prester, Granic, and Orct (2008) stated that the temperature in the house at weeks 1, 2, 3, 4, 5 respectively was 31.05; 27.34; 26.04; 24.17 and 22.02°C. The temperature in the fourth week is between 28.7 – 29.8°C (Sohsuebngarm, Kongpehr, and Sukon 2019), and the 5th is between 18 – 22°C

(Alimuddin, Seminar, Subrata, Nomura, and Sumiati, 2012). Open houses are usually built in the highlands where the air is cooler, while semi-open and closed houses can be built both in the highlands and lowlands. The semi-enclosed house is equipped with a fan and fogger as a cooling system and helps circulate air inside the house. The temperature in the semi-enclosed house in this study was high in week three because the fogger, which was supposed to help with the cooling system, experienced technical problems. The density in semi-closed houses is greater than in open houses with the same area. The closed house is equipped with a cooling system inside the house, namely cooling pad and exhaust fan. In this study, closed houses also had high temperatures in the 3rd and 4th weeks. It can be assumed that this occurred because the existing cooling system could not cope with the high density of the houses. In addition to the factors mentioned above, ambient temperature also affects the temperature inside the house, although the effect is not as big as in open and semi-closed houses. This research was conducted during the dry season where the ambient temperature was relatively higher than during the rainy season. In this season the air temperature tends to be quite hot, which is around 28°-34°C during the day. At night, the air temperature will drop to around 21°-25°C (BMKG, 2022).

Relative humidity

Based on the data in table 1. different types of houses have a significant effect on humidity. During the production phase the relative humidity must be set to be in the range of 60 – 70%, with an optimal value of 65% (Radon, Bieda and Nawalany, 2004). Vucemilo et al (2008) stated that RH in the first week was 49.55%, the second week was 52.48%, the third week was 59.23%, the fourth week was 65.45% and the fifth week was 60.18%. The humidity level from the research results is generally in the normal range. If the humidity is low, the environment will become dusty, whereas if it is higher, the litter will become wet, both of these things will have a negative impact on the comfort and health of livestock which will ultimately have a negative impact on livestock productivity. Humidity is closely related to temperature, if the temperature is high then the humidity is low and if the temperature is low then the humidity is high. However, tropical countries have higher humidity levels than subtropical countries.

Wind velocity

Ventilation is an important factor in controlling house temperature and relative humidity and plays a role in reducing the negative effects of house density and wet litter (Bianchi, Giametta, Fianza, Gentile and Catalano, 2015). Air circulation in open houses comes from the ventilation on each side of the house, in closed houses as well as adding fans to support natural air circulation. Wind speed is measured to find out how much air circulation is in the house. Wind speed can change at any time. The wind speed in the open enclosure is highly dependent on the environmental wind speed. In a semi-closed house, apart from being influenced by the environment, it is also added by the fan in the house. In closed houses this function is replaced by a blower which is at one end of the house, so that the older the chickens and the higher the ambient temperature, the wind speed is increased to keep the temperature and humidity inside the house within the range of the chicken's comfort zone.

Table 1 shows that the type of house has a significant effect ($P<0.05$) on wind speed in the third and fourth week. In the second week the wind speed was not significantly different. In the third and fourth weeks the wind speed in open and semi-closed houses was significantly different compared to closed houses, the average wind speed in closed houses was the highest, namely 0.71 ± 0.80 m/s and 1.06 ± 1.31 m/s . This is because in a closed house air circulation comes from the shape of the house in the form of a tunnel equipped with an air inlet and exhaust fan to remove hot and dirty air from inside the house, so a higher wind speed is needed. Wind speeds

of 2m/s in closed houses can increase heat release by convection, resulting in reduced heat stress and mortality (DEFRA, 2008). This is supported by Daghir (2008), which states that wind speed in broiler houses is in the range of 2.5 – 3 m/s. The research results of Arifudin, Bachelor, Muryani, Mahfudz, Sunarti, Sarengat and Angkeke (2018) show that the wind speed in closed houses in the dry season in zones 1, 2, 3 and 4 respectively is 1.90 m/s, 1, 39m/s, 1.11m/s and 0.72m/s.

NH3

Levels

High ammonia concentrations in broiler houses have a negative effect on poultry performance, feed efficiency and livestock welfare. To maximize the performance and health of the flock, the ammonia concentration must remain at a level of 25 - 50 ppm (Miles et al., 2004). Ammonia concentrations in houses are usually higher than recommended levels. Ammonia concentration is influenced by many factors such as temperature, humidity (Cemek, Kucuktopcu and Demir, 2016) and manure management (David, Medjell, Michel, Lund and Moe, 2015). Most of the ammonia comes from the decomposition of nitrogen-containing excretions from the kidneys and intestines of poultry. Nitrogen is excreted as uric acid (80%), ammonia (10%), and urea (5%). Once excreted, uric acid and urea are easily converted to ammonia by a series of microbial enzymes present in the excreta and by microbial degradation. Water (or moisture) is necessary for the growth of microorganisms and for the function of enzymes to convert uric acid into urea. Bacillus pasteurii is one of the main uricolytic bacteria that facilitates the production of ammonia in houses (Tasistro, Ritz and Kissel, 2007).

Table 2. Level of NH_3 in open, semi closed and closed houses

Week	Open house	Semi closed house	Closed house
2	1.61 ± 0.72^a	0.27 ± 0.48^a	3.69 ± 3.18^b
3	3.13 ± 0.89^a	3.01 ± 2.45^a	9.08 ± 3.61^b
4	2.19 ± 1.17^a	6.79 ± 5.08^a	16.36 ± 8.94^b

Note: different superscripts on the same line indicate a significant difference ($p<0.05$)

Table 2 shows that NH_3 was significantly different ($P<0.05$) between open and semi-closed houses and closed houses. In the second week, the values were 1.61 ± 0.72 ppm, 0.27 ± 0.48 ppm, and 3.69 ± 3.18 ppm, respectively. The third week was 3.13 ± 0.89 ppm, 3.01 ± 2.45 ppm, and 9.08 ± 3.61 ppm. In the fourth week, it was 2.19 ± 1.17 ppm, 6.79 ± 5.08 ppm, and 16.36 ± 8.94 ppm. The value is still below the threshold that chickens can tolerate. The results of the above study are in line with Vucemilo et al. (2008); ammonia levels in the second week were 8.34 ppm, in the third week were 16.22 ppm and in the fourth week were 18.87 ppm. Based on the data in table 2, ammonia levels have increased from the second and third to the fourth week. The average ammonia concentration usually increases with age (Cemek, et al., 2016). However, in closed houses, the concentration was much higher. This is presumably because the higher density of houses in closed houses is the cause, coupled with high temperature and humidity, which are the main factors causing high ammonia levels.

coli

Escherichia coli is one of the microorganisms that cause morbidity and mortality in broilers and causes economic losses in the poultry industry. *E. coli* can be transmitted to humans through contact, chicken meat, and eggs. The intestinal tract is the source of these pathogenic bacteria, where excreta and dust make it more widespread. Cleaning and disinfecting houses are the keys to controlling e coli (Timothi, Shafi, Laetherbarrow, Jordan, and Wigley, 2008).

Table 3. Level of *E. coli* in open, semi closed and closed houses

Week	Open house	Semi closed house	Closed house
2	2.10 ± 0.93[a]	3.28 ± 1.17[a]	3.63 ± 1.71[a]
4	3.40 ± 1.91[a]	4.58 ± 0.94[a]	5.78 ± 2.54[a]

Note: different superscripts on the same line indicate a significant difference (p<0.05)

In this study, *E. coli* in the dry season was not significantly different between open, semi-closed, and closed houses. The values can be seen in table 3, where the lowest to highest values are open, semi-closed, and closed houses, respectively. This is presumably due to the different densities of the houses among the three houses causing the difference in the number of *E. coli*. *E. coli* in the litter is an accumulation of *E. coli* in excreta.

The higher density of houses in semi-closed and closed houses is probably the reason for the high number of *E. coli*. The results of research by De Rezende, Mallinson, Tablante, Morales, and Park (2001) showed that the number of *E. coli* in the litter was 8.2 x 105 – 5.4 x 106 CFU/10.0 g litter. The number of *E. coli* in ceca and litter was log 7 CFU/g and log 6 CFU/g, respectively (Chinivasagam, Estella, Rodgrigues, Mayer, Weyand<tran, Onysk, and Dialo, 2016).

Broiler productivity

Feed Consumption

Poultry productivity is not only influenced by genetic factors but also environmental factors. Optimum broiler consumption and body weight can be achieved if kept in a comfort zone (Al-Aqil, Zulkifli, Sazili, Omar, and Rajion, 2009). The effect of the type of house on the weight of broilers in the dry season can be seen in table 4.

Table 4. The effect of housing type on body weight

Age (days)	Body weight (g/bird)		
	Open house	Semi closed house	Closed house
1	42.09 ± 3.17[a]	44.51 ± 3.67[b]	45.52 ± 4.76[c]
7	211.38 ± 21.23[c]	197.91 ± 29.72[b]	184.33 ± 27.87[a]
14	545.53 ± 59.79[c]	506.62 ± 86.56[a]	509.70 ± 50.19[b]
21	1,078.80 ± 119.28[c]	917.80 ± 189.65[a]	1,035.30 ± 107.03[b]
28	1,364.00 ± 197.19[a]	1,339.90 ± 194.67[a]	1,395.00 ± 189.40[b]

Note: different superscripts on the same line indicate a significant difference (p<0.05)

Based on table 4, it can be seen that the type of house has a significant effect on body weight (P<0.05). At the age of 7 - 21 days, the BB in the open house was the highest, while at the age of 28, the BB was the highest in the closed house. This study's results differ from the results of research by Anggraeni and Febrianti (2018), which stated that the body weight in the first week of closed houses was 198 g/bird. Open houses were 178 g/bird; in the second week, closed houses were 494 g/bird, and open houses were 464 g/bird. Al-Aqil et al. (2009), at 21 days old closed house weight of 801 ± 9.58 g/bird and open house 750 ± 19.82 g/bird; at 28 days old closed house weight of 1308 ± 971 g/bird and open house 1218 ± 11.06 g/bird.

The high BB aged 7-21 days in open and semi-closed houses is thought to be due to the influence of temperature, humidity, and ammonia levels. In a closed house, the temperature and density of the house have the highest values (can be seen in table 1). The temperature inside the house is not only influenced by ambient temperature but also by the temperature of the heater/brooder and also the chicken's body heat, which is the result of metabolism. At the age of 28 days, BB in closed houses is the highest; this is probably because even though the temperature, humidity, ammonia levels, and

density of the house are high, it is supported by good air circulation in the house, where the wind speed is increased so that the chickens get the wind chill effect.

Feed Intakes

Feed Intake (FI) is the most important factor determining the growth rate of broilers (Abdollahi, Zaefarian, and Ravindran, 2018). Increased FI can increase weight gain. In order to maximize genetic potential and take advantage of modern broiler appetites, it is critical to minimize the factors that lead to reduced FI. Many factors affect FI, namely feed from chickens (feed form, nutrient density, and anti-nutrient factors), management (stocking density, temperature, lighting, stress, and water supply), and factors of the chicken itself (genotype, sex, age, and capacity digestive tract) (Applegate, 2012).

Table 5. The effect of housing type on FI, FCR, IP, mortality and IOFC

Parameters	Open house	Semi closed house	Closed house
FI (kg)	2.31 ± 0.03[a]	2.23 ± 0.03[a]	2.33 ± 0.02[a]
FCR	1.58 ± 0.04[a]	1.49 ± 0.02[a]	1.61 ± 0.01[a]
IP	324.50 ± 12.02[a]	376.50 ± 17.68[a]	313.50 ± 0.71[a]
Mortality (%)	2.43 ± 0.07[a]	2.49 ± 0.23[a]	2.13 ± 0.22[a]
IOFC (Rp)	9,690.90 ± 310.32[a]	9,975.50 ± 472.99[a]	9,292.50 ± 68.53[a]

Note: different superscripts on the same line indicate a significant difference ($p<0.05$)

Based on table 5, the type of house does not affect FI. Successively from lowest to highest, semi-closed, open, and closed houses, 2.23 ± 0.03 kg, 2.31 ± 0.03 kg, and 2.33 ± 0.02 kg. These results are higher when compared to the results of the study by Soliman et al. (2021) FI in the first, second, third, and fourth weeks respectively, namely 135.7 ± 2.2 g, 309.4 ± 1.3 g, 694.6 ± 2.4g and 761.8 ± 1.9g. Respati, Hakim, and Kusuma (2020) stated that the FI of the open and closed house at five weeks of age was 3,300 g and 3,400 g, respectively.

FCR

The feed Conversion Ratio is a value that indicates how efficient the amount of feed consumed by chickens is for growth or weight gain in a certain period. If the FCR value decreases, the feeding is more effective, and the chickens have optimally converted the feed into meat (Laili, Damayanti, Setiawan, and Hidanah, 2022). The study results in table 5 show that the type of house does not affect FCR. The FCR values from lowest to highest were semi-closed, open, and closed houses, respectively 1.49 ± 0.02, 1.58 ± 0.04, and 1.61 ± 0.01. The FCR was obtained following the results of Respati et al. (2020) study, where it was 1.61 in an open house and 1.64 in a closed house. Soliman et al. (2021) stated that the FCR of the first, second, third, and fourth weeks was 2.0 ± 0.06, 0.8 ± 0.03, 1.4 ± 0.06, and 1.4 ± 0.05.

Performance Index

The Performance Index is a measure that shows the value of the farmer's success in the business of raising broiler chickens seen based on the number of live chickens, harvest weight, harvest age, and FCR value (Laili et al., 2022). The higher the IP value, the better the productivity of a farm. The performance index can be used as a guideline for determining broiler productivity, grouped into four values >400 is very good, values 350-400 are said to be good, values 300-350 are said to be quite good, and values <300 are said to be not good (Sufiriyanto, Hidayat, Indrasanti, Nugroho and Harwanto , 2020). In table 5, it is known that the type of house does not affect IP. The IP values from lowest to highest were closed, open, and semi-closed houses, respectively, namely 313.50 ± 0.71%, 324.50 ± 12.02%, and 376.50 ± 17.68%. Even though the statistics were not significantly different, the IP in the closed and open houses was quite good, while the IP in the semi-closed houses was in a good category. The results of Laili et al.'s research

(2022) on the IP value in closed-house system houses were 366.5%, while in open-house system houses, it was 319.4%. The same results were reported by Respati et al. (2020); the IP value in open houses was 336% and 328% in closed houses.

Mortality

Mortality is one important factor that must be considered in a broiler farming business. The welfare of chickens can be reflected in the mortality rate (Martindah and Dhenastri, 2020). Many factors influence broiler mortality. According to Yerpes, Ilonch, and Manteca (2020), mortality in the first week is influenced by breeder age, doc sex, breed, type of broiler house, presence or absence of drip cups, egg storage, and study season. Therefore, these factors should be key in poultry company decision-making to reduce welfare problems and increase poultry productivity.

The percentage of mortality in this study was not affected by the house type. Mortality to rearing rates in the fourth week from lowest to highest were closed houses, open houses, and semi-closed houses, respectively, 2.13 ± 0.22%, 2.43 ± 0.07%, respectively, and 2.49 ± 0.00, respectively—23%. The results are quite good because the mortality rate is below 5%. According to Andri, Ismoyowati, Rahayu, Nur, and Voni (2021), the death rate is said to be good if it is below 5%. The results are in line with the results of Wurlina's study (2012), where mortality ranged from 1.9% to 2.4%. Andri et al. (2021), the percentage of mortality in open houses was 4.704% and 4.491% in closed houses. Setiadi, Bachelor, Santoso, and Nurfadila (2021) stated that mortality in open houses was 11.5%, while in closed houses, it was 0.98%. Attapattu, Abeywicakrama, Gunawardane, and Munasinghe (2017) reported that mortality in open houses was 4.52 ± 3.75% and that in closed houses was 3.36 ± 1.59%.

Low-quality DOC seeds that are not matched by good maintenance management indirectly increase mortality, especially during the brooder period. Health management includes disease prevention with biosecurity and disease management by administering drugs and vitamins that are carried out properly will support the health condition of chickens to prevent the percentage of livestock deaths (Andri et al., 2021).

IOFC

The IOFC value is calculated based on the feed cost incurred during rearing and the selling price of broilers at harvest. The large amount of feed consumed by livestock during rearing can affect the IOFC value obtained (Syaefullah, Herawati, Timur, Bachtiar, and Maulana, 2019). Nurdiyanto, Sutrisna, and Nova (2015) stated that increased ration consumption would lead to increased livestock production costs.

IOFC in this study can be seen in table 5. Based on the study's results, the house type did not affect IOFC. IOFC from lowest to highest are closed, open, and semi-closed, respectively Rp 9,292.50 ± 68.53; IDR 9,690.90 ± 310.32; IDR 9,975.50 ± 472.99. Nuningtyas (2014) states that the IOFC of broilers ranges from IDR 8,430.8 ± 620.77 – IDR 10,150.8 ± 569.26. The research results by Anggitasari, Sjofjan, and Djunaidi (2016), IDR 9,284 ± 1,341.27 – IDR 10,952 ± 563.85.

CONCLUSION

All houses' temperature, humidity, and wind speed range are still within the standard range of broiler maintenance. NH_3 levels were below the threshold that chickens could tolerate, although the highest levels were in closed houses and *E. coli*. This affects the body weight of broilers in open and semi-closed houses at weeks 1, 2, 3, which is higher than in closed houses. FI, FCR, IP, mortality, and IOFC were not significantly different in all houses.

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