



Performance comparison of broiler chickens reared in closed versus stage slatted-floor open-sided houses: a case study of broiler farmers under an inti-plasma partnership model in Indonesia

Zulfan Zulfan^{*} , Muhammad Daud and Fizalul Ikram

Animal Husbandry Department, Faculty of Agriculture, Syiah Kuala University, 24415, Banda Aceh, Indonesia. ^{*}Author for correspondence. E-mail: zulfan_pet@yahoo.co.id

ABSTRACT. Over the last few decades, the Indonesian government has designed a partnership model for the farming system called an inti-plasma model. An *inti* or a core was a large private company, while the plasmas were smallholders that collaborated with the core. In the subsector of animal husbandry, the animal housing system has been considered the main regulation to achieve a contract between the core and plasmas. This study aimed to evaluate the performance comparison of broiler chickens kept in the closed house (CH) versus those kept in the stage slatted-floor open-sided house (OH) at broiler farms in Desa Simpang Jambe, Indonesia, in partnership with Charoen Pokphan Jaya Farm. This study was conducted in a completely randomized design (CRD) with two treatments and ten replications. The treatments were broilers reared in CH, and those in the OH. Each replication was an experimental unit with 4,800 birds pen⁻¹ in the CH and 600 birds pen⁻¹ in the OH. Twenty birds were randomly sampled from each pen for body weight (BW) and feed intake (FI), resulting in 200 sampling birds from each house. Data were analyzed using a t-test analysis. The results of this study showed that during the starter period, BW, body weight gain, feed intake, mortality, and depletion were significantly better at $p < 0.05$ and $p < 0.01$ in the OH than in the CH, but feed conversion ratio was not significantly different at $p > 0.05$ between both houses. However, during the grower/finisher and overall periods, all performance parameters were significantly different ($p < 0.01$) by house type. In conclusion, producing broilers at 4 or 5 weeks of marketed ages in the closed house performed better performance index than those in the stage slatted-floor open-sided house.

Keywords: broiler, housing, collaboration pattern, performance index.

Received on October 30, 2024.

Accepted on May 5, 2025.

Introduction

The problem with small-scale broiler farming in Indonesia was that they commonly had low investment. In the past, many small holders produced broiler chickens in the concrete-floor open-sided house system due to low construction costs. As the farmers increased their production capacity, there was a need extra fund to pay for variable costs, and their products sometimes were not marketable. In this situation, the farmers maintained their broilers at the capacity they can sell. They might get a low margin and even none. Many farms in the hot region did not support the broilers in achieving a maximum performance index due to heat stress. Litters covering the concrete floor helped the young chicks to keep warm, but it shortly became hazards when the birds grew bigger. Studies have shown that open-sided housing systems result in higher poultry mortality rates due to unfavourable environmental conditions affecting the birds (Sumarno & Supartini, 2022; Farida et al., 2022; Laili et al., 2022).

Over the last few decades, the Indonesian government has designed a partnership model for developing rural animal industries called an inti-plasma pattern. An *inti* is a core belonging to a private company, while the plasmas are the smallholders. One of the goals of this system is to increase farmer's farm capacity (Direktorat Pengolahan dan Pemasaran Hasil Peternakan, 2017). The smallholders mostly use a concrete-floor open-sided housing system to produce broilers chicken because of low construction cost. Commonly, the core provides capital loans to the plasmas. There are various collaboration models in which all agreements are incorporated into the moratorium of understanding. In the broiler industry, currently, the plasmas are not permitted to set up open-sided houses with litter rather than slatted floors. The core supplies all production inputs such as day old chick (DOC), feeds, vitamins, medicines, and vaccines to the plasmas on the loan schemes. At the harvesting time, the company buys all the farmer products and resells them back into the global markets. The plasmas could only earn a profit after paying off their debt. This pattern has successfully stimulated the farmers to increase their farming capacity.

A high stocking density of broilers is less suitable for open-sided housing compared to environmentally controlled systems, as the latter provides optimal thermal regulation, reduces environmental stressors, and minimizes mortality risks associated with fluctuating climatic conditions. However, the high initial investment required for environmentally controlled housing poses a financial challenge for many farmers, limiting its widespread adoption. Some farmers have adopted this system, but others are hesitant. Earlier studies reported that the broiler performance index (PI) produced in modern closed houses was better than that in the conventional houses (Pakage et al., 2020; Farida et al., 2022). On the other hand, some researchers reported that a broiler PI was higher in open houses than in closed houses due to low mortality (Nuryati, 2019). Typically, litter floors create poor odours, such as ammonia emitted from the wet manures. The slatted floors can minimize this condition by allowing this compound to pass the slats' holes out of the cages. This study aimed to evaluate the performance comparison of broiler chickens kept in the closed house and stage slatted-floor open-sided house systems at the chicken broiler farmers in Desa Simpang Jambe, Simpang Keuramat District, North Aceh Regency, Indonesia, in partnership with Charoen Pokphan Jaya Farm, co.

Materials and method

Place and time

This study took place at two broiler farms which were Rifal's Farm with a closed house system and Iswandi's Farm with a stage slatted-floor open-sided house system located in Desa Simpang Jambe, Simpang Kramat District, North Aceh, Indonesia. These farms collaborated with Charoen Pokphand Jaya Farm, Medan, Indonesia, under an inti-plasma partnership model. Rifal's Farm started in 2018 with an open-sided house for 6,000 broilers. In 2020, the housing was renovated into a semi-closed house for a total of 15,000 broilers, and then in 2021, upgraded into a closed house for 48,000 broilers. Iswandi's Farm started in 2021 with a stage slatted-floor open-sided house for 6,000 broilers.

Animals and houses

A total of 48,000 broiler chickens were reared in a closed house (CH) 120 x 12 m (double deck), and 6,000 were reared in a stage slatted-floor open-sided house (OH) 80 x 8 m with wood slat floor (single deck). These farms were operated under the system of the inti-plasma partnership model. The broiler strain was CP707 produced by Charoen Pokphand Jaya Farm, Medan, Indonesia, a core farm that delivered the chicks and other inputs to the plasmas' farms. Both houses were split into ten pens consisting of 4,800 broilers per pen in the CH and 600 broilers per pen in the OH. Feed was delivered automatically in the CH but manually provided *ad libitum* in the OH. Both houses supplied drinking water automatically. All environmental factors were controlled in the CH but none in the OH.

Treatments and experimental design

This study was performed in a completely randomized design (CRD) consisting of two treatments and ten replications. The treatments were broilers reared in the closed house (CH), and those in the stage slatted-floor open-sided house (OH). Each replication was an experimental unit occupying 4,800 birds per pen in the CH and 600 birds per pen in the OH, based on farms' condition. Twenty birds from each pen were sampled randomly for body weight (BW) and feed intake (FI), thus resulting in 200 sampling birds from each house. The CH and OH systems conducted in this study are presented in Figure 1.



(a)



(b)

Figure 1. (a) Rifal's Farm with a closed house system and (b) Iswandi's Farm with a stage slatted-floor open-sided house system.

Parameters and data collections

An average BW was measured on the first day when the chicks were placed in the house and recorded as DOC weight, then reweighted at the end of each week, thus recorded as BW each week. Body weight at the end of the 3rd week was recorded as final body weight (FBW) at the starter period, and BW at the 5th week was recorded as final body weight (FBW) for overall periods. The number of birds weighed was 20 broilers from each pen selected randomly and expressed in gram bird⁻¹ of the average BW.

An average body weight gain (WBWG) each week was calculated by subtracting the average BW at the end of the current week ($BW_{\text{week } n}$) from the average BW at the end of the previous week ($BW_{\text{week } n-1}$). An average WBWG during 3 weeks was recorded as a WBWG starter, and obtained by subtracting BW at the end of the 3rd week from BW at DOC, then dividing by 3. An average WBWG during the grower/finisher was computed by subtracting BW at the end of the 5th from BW at the end of the 3rd week, then dividing by 2. An overall WBWG was calculated by subtracting BW at the end of the 5th from BW at DOC, then dividing by 5. An average WBWG for up to n-weeks was computed by subtracting BW at the end of the nth week ($BW_{\text{week } n}$) from BW at DOC (BW_{DOC}) divided by n week. The formulas for computing WBWG were as follows:

$$WBWG_{\text{starter}} = \frac{(BW_{\text{week } 3} - BW_{\text{DOC}})}{3}$$

$$WBWG_{\text{grower/finisher}} = \frac{(BW_{\text{week } 5} - BW_{\text{week } 3})}{2}$$

$$WBWG_{\text{overall}} = \frac{(BW_{\text{week } 5} - BW_{\text{DOC}})}{5}$$

$$WBWG_{\text{week } n} = BW_{\text{week } n} - BW_{\text{week } (n-1)}$$

$$WBWG_{n \text{ week}} = \frac{(BW_{\text{week } n} - BW_{\text{DOC}})}{n}$$

Feed intake (FI) was determined according to the farm practices of rearing the birds commercially. Under farm management of a closed house, the feed was delivered automatically to all the feeders in the pens, and spent feed was recorded daily. Then, an average daily feed intake (DFI) was recorded by dividing the total feed distributed to all pens by the number of birds living in a house. It was not the real average feed intake (AFI) since there were some residual feeds left in the feeders. The AFI should be computed by subtracting an average given feed (AGF) from an average residual feed (ARF). In this study, it was not easy to compute AGF per pen because feed was distributed by a single hopper to all feeders in the pens. In an assumption that the feeds were distributed to each pen in an equal amount for all pens, an AFI per bird was counted by dividing the total feed given (TFG) by the total birds living in the house. Therefore, each bird was assumed to take feeds in the same amounts. An AFI per bird in each pen can be computed by subtracting an AFI from the AFR per bird in the pen. An AFR per bird was calculated as follows: 20 feeders in a pen were chosen randomly and then the feed residue was removed from each feeder, combined, and weighed entirely. An AFR per feeder of the sampling feeders was computed by dividing the sampling feed residue weight by 20 feeders. The total feed residue (TFR) in a pen was estimated by multiplying an average sampling FR by the total feeders in a pen. Then, an AFR per bird was computed by dividing TFR by the number of birds living in the pen. Finally, an AFI per bird per pen was calculated by subtracting an AFG from an AFR per bird. Under the farm management of the open-sided house system, feeds were delivered manually so that an AFG per bird per pen could be easily computed, but it did not agree with the closed house. Therefore, in this study, the computation of AFI was similarly done for both houses. Formulas for computing weekly feed intake were as follows:

$$WFI_{\text{starter}} = \frac{TFI_{1-3 \text{ week}}}{3}$$

$$WFI_{\text{grower/finisher}} = \frac{TFI_{4-5 \text{ week}}}{2}$$

$$WFI_{\text{overall}} = \frac{TFI_{1-5 \text{ week}}}{5}$$

$$WFI_{\text{week } n} = FI_{\text{week } n} - FI_{\text{week } (n-1)}$$

$$WFI_{n \text{ week}} = \frac{TFI_{n \text{ week}}}{n}$$

Average FCR was measured by dividing average WFI by average WBWG with the formulas as follows:

$$\begin{aligned} \text{FCR}_{\text{starter}} &= \frac{\text{WFI}_{1-3 \text{ week}}}{\text{WBWG}_{1-3 \text{ week}}} \\ \text{FCR}_{\text{grower/finisher}} &= \frac{\text{WFI}_{4-5 \text{ week}}}{\text{WBWG}_{4-5 \text{ week}}} \\ \text{FCR}_{\text{overall}} &= \frac{\text{WFI}_{1-5 \text{ week}}}{\text{WBWG}_{1-5 \text{ week}}} \\ \text{FCR}_{\text{week } n} &= \frac{\text{WFI}_{\text{week } n}}{\text{WBWG}_{\text{week } n}} \\ \text{FCR}_{n \text{ week}} &= \frac{\text{WFI}_{n \text{ week}}}{\text{WBWG}_{n \text{ week}}} \end{aligned}$$

Average FER was measured by dividing average WBWG by average WFI with the formulas as follows:

$$\begin{aligned} \text{FER}_{\text{starter}} &= \frac{\text{WBWG}_{1-3 \text{ week}}}{\text{WFI}_{1-3 \text{ week}}} \\ \text{FER}_{\text{grower/finisher}} &= \frac{\text{WBWG}_{4-5 \text{ week}}}{\text{WFI}_{4-5 \text{ week}}} \\ \text{FER}_{\text{overall}} &= \frac{\text{WBWG}_{1-5 \text{ week}}}{\text{WFI}_{1-5 \text{ week}}} \\ \text{FER}_{\text{week } n} &= \frac{\text{WBWG}_{\text{week } n}}{\text{WFI}_{\text{week } n}} \\ \text{FER}_{n \text{ week}} &= \frac{\text{WBWG}_{n \text{ week}}}{\text{WFI}_{n \text{ week}}} \end{aligned}$$

Mortality (Mor) each week was recorded by dividing the number of dead birds (DB) within the current week by the number of living birds (LB) at the end of the last week. Mortality during the starter period (Mor_{starter}) was recorded by dividing the number of dead birds for up to 3 weeks by the initial total number of birds (ITB). Mortality during the grower/finisher (Mor_{grower/finisher}) was recorded by dividing the number of dead birds at the 4th and 5th weeks by the number of living birds at the end of the 3rd week. Overall mortality (Mor_{overall}) was recorded by dividing the number of dead birds during the study by the initial total number of birds. Mortality for up to n weeks (Mor_{n week}) was recorded by dividing the number of dead birds during n weeks (DB_{n week}) by the initial total number of birds (ITB). The formulas for calculating mortality were as follows:

$$\begin{aligned} \text{Mor}_{\text{starter}} &= \frac{\text{DB}_{1-3 \text{ week}}}{\text{ITB}} \times 100\% \\ \text{Mor}_{\text{grower/finisher}} &= \frac{\text{DB}_{4-5 \text{ week}}}{\text{LB}_{\text{week } 3}} \times 100\% \\ \text{Mor}_{\text{overall}} &= \frac{\text{DB}_{1-5 \text{ week}}}{\text{ITB}} \times 100\% \\ \text{Mor}_{\text{week } n} &= \frac{\text{DB}_{\text{week } n}}{\text{LB}_{\text{week } (n-1)}} \times 100\% \\ \text{Mor}_{n \text{ week}} &= \frac{\text{DB}_{n \text{ week}}}{\text{ITB}} \times 100\% \end{aligned}$$

Culling (Cul) was measured the same way as calculating mortality, but it was only recorded for culled birds with the formulas as follows:

$$\begin{aligned} \text{Cul}_{\text{starter}} &= \frac{\text{CB}_{1-3 \text{ week}}}{\text{ITB}} \times 100\% \\ \text{Cul}_{\text{grower/finisher}} &= \frac{\text{CB}_{4-5 \text{ week}}}{\text{LB}_{\text{week } 3}} \times 100\% \\ \text{Cul}_{\text{overall}} &= \frac{\text{CB}_{1-5 \text{ week}}}{\text{ITB}} \times 100\% \\ \text{Cul}_{\text{week } n} &= \frac{\text{CB}_{\text{week } n}}{\text{LB}_{\text{week } (n-1)}} \times 100\% \end{aligned}$$

$$\text{Cul}_{n \text{ week}} = \frac{\text{CB}_{n \text{ week}}}{\text{ITB}} \times 100\%$$

Depletion (Dep) was measured by adding the mortality to the culling with the formulas as follows:

$$\text{Dep}_{\text{starter}} = \text{Mor}_{\text{starter}} + \text{Cul}_{\text{starter}}$$

$$\text{Dep}_{\text{grower/finisher}} = \text{Mor}_{\text{grower/finisher}} + \text{Cul}_{\text{grower/finisher}}$$

$$\text{Dep}_{\text{overall}} = \text{Mor}_{1-5 \text{ week}} + \text{Cul}_{1-5 \text{ week}}$$

$$\text{Dep}_{\text{week } n} = \text{Mor}_{\text{week } n} + \text{Cul}_{\text{week } n}$$

$$\text{Dep}_{n \text{ week}} = \text{Mor}_{n \text{ week}} + \text{Cul}_{n \text{ week}}$$

Liveability (Liv) was recorded by subtracting 100% from the depletion (Dep) with the formulas as follows:

$$\text{Liv}_{\text{starter}} = 100 - \text{Dep}_{1-3 \text{ week}}$$

$$\text{Liv}_{\text{grower/finisher}} = 100 - \text{Dep}_{\text{grower/finisher}}$$

$$\text{Liv}_{\text{overall}} = 100 - \text{Dep}_{\text{overall}}$$

$$\text{Liv}_{\text{week } n} = 100 - \text{Dep}_{\text{week } n}$$

$$\text{Liv}_{n \text{ week}} = 100 - \text{Dep}_{n \text{ week}}$$

Average performance index (PI) was determined using the data obtained from the liveability, BW, FCR, and bird's age during n-week observation with the formula as follows:

$$\text{PI}_{1 \text{ week}} = \frac{(\text{Liv}_{1 \text{ w}} \times \text{kg BW}_{1 \text{ week}})}{7 \times \text{FCR}_{1 \text{ week}}} \times 100\%$$

$$\text{PI}_{1-2 \text{ week}} = \frac{(\text{Liv}_{1-2 \text{ w}} \times \text{kg BW}_{\text{week } 2})}{14 \times \text{FCR}_{1-2 \text{ week}}} \times 100\%$$

$$\text{PI}_{1-3 \text{ week}} = \frac{(\text{Liv}_{1-3 \text{ w}} \times \text{kg BW}_{\text{week } 3})}{21 \times \text{FCR}_{1-3 \text{ week}}} \times 100\%$$

$$\text{PI}_{1-4 \text{ week}} = \frac{(\text{Liv}_{1-4 \text{ week}} \times \text{kg BW}_{\text{week } 4})}{28 \times \text{FCR}_{4 \text{ week}}} \times 100\%$$

$$\text{PI}_{1-5 \text{ week}} = \frac{(\text{Liv}_{1-5 \text{ week}} \times \text{kg BW}_{\text{week } 5})}{35 \times \text{FCR}_{1-5 \text{ week}}} \times 100\%$$

Analyses the data

Data were tabulated based on parameters and then analyzed using a t-test with the program SPSS 16 (Ott, 1991).

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

The notation represents as follow: $\bar{X}_1$ = mean of CH, $\bar{X}_2$ = mean of OH, S_1 = standard deviation of CH, S_2 = standard deviation of OH, n_1 = the number of observations of CH, and n_2 = the number of observations of OH.

Results

Broilers' performances per period

Broiler performances during the starter (weeks 1 to 3), grower/finisher (weeks 4 to 5), and overall periods (weeks 1 to 5) reared in a closed house (CH) versus in a stage slatted-floor open-sided house (OH) at Rifal's and Iswandi's Farms are presented in Table 1. Analysis of variances indicated that during the starter period, some broilers' performance parameters, such as body weight (BW) and body weight gain (BWG), were significantly different at $p < 0.05$. Some of those, such as feed intake (FI), mortality, and depletion, were significantly different at $p < 0.01$, while the others, such as feed conversion ratio (FCR) and feed efficiency ratio (FER), were not significantly different at $p > 0.05$. However, during the grower/finisher and overall periods, all performance parameters were significantly different at $p < 0.01$ by house type. The final performances of broilers reared in both houses are given in Figure 2.

Table 1. Performances of broilers reared in the closed and the stage slated-floor open-sided house during the periods of rearing.

Parameters	Housing type	Periods of rearing		
		Starter (1 to 3 weeks)	Grower/finisher (4 to 5 weeks)	Overall (1 to 5 weeks)
Body weight (g b ⁻¹ w ⁻¹)	CH	925±18.02 ^B	2295±11.79 ^a	2295±11.79 ^a
	OH	942±13.17 ^A	1930±47.84 ^b	1930±47.48 ^b
	p-value	0.025	0.000	0.000
Weekly body weight gain (g b ⁻¹ w ⁻¹)	CH	294±6.00 ^B	685±13.04 ^a	450±2.36 ^a
	OH	299±4.39 ^A	494±25.53 ^b	377±9.57 ^b
	p-value	0.026	0.000	0.000
Daily body weight gain (g b ⁻¹ d ⁻¹)	CH	41.93±0.86 ^B	97.89±1.86 ^a	69.94±2.91 ^a
	OH	42.74±0.63 ^A	70.59±3.65 ^b	53.88±1.37 ^b
	p-value	0.026	0.000	0.000
Total feed intake (g b ⁻¹)	CH	1273±3.36 ^b	2208±3.44 ^a	3481±0.12 ^a
	OH	1293±3.04 ^a	2028±3.31 ^b	3325±0.76 ^b
	p-value	0.000	0.000	0.000
Weekly feed intake (g b ⁻¹ w ⁻¹)	CH	424±1.12 ^b	1104±1.72 ^a	696±0.03 ^a
	OH	432±1.01 ^a	1014±1.66 ^b	665±0.15 ^b
	p-value	0.000	0.000	0.000
Daily feed intake (g b ⁻¹ d ⁻¹)	CH	60.62±0.16 ^b	157.72±0.25 ^a	99.46±0.00 ^a
	OH	61.76±0.15 ^a	144.88±0.24 ^b	95.01±0.02 ^b
	p-value	0.000	0.000	0.000
Feed conversion ratio	CH	1.45±0.03	1.61±0.03 ^a	1.55±0.01 ^a
	OH	1.45±0.02	2.06±0.11 ^b	1.76±0.04 ^b
	p-value	0.091	0.000	0.000
Feed efficiency ratio	CH	0.69±0.01	0.62±0.01 ^a	0.65±0.00 ^a
	OH	0.71±0.01	0.45±0.02 ^b	0.54±0.01 ^b
	p-value	0.091	0.000	0.000
Mortality (%)	CH	1.00±0.22 ^a	0.86±0.18 ^a	1.86±0.21 ^a
	OH	1.41±0.37 ^b	1.78±0.47 ^b	3.19±0.50 ^b
	p-value	0.008	0.000	0.000
Culling (%)	CH	0.45±0.16	0.15±0.10 ^a	0.61±0.22 ^a
	OH	0.69±0.38	0.67±0.24 ^b	1.35±0.51 ^b
	p-value	0.094	0.000	0.001
Depletion (%)	CH	1.45±0.24 ^a	1.01±0.13 ^a	2.47±0.15 ^a
	OH	2.10±0.36 ^b	2.45±0.30 ^b	4.54±0.33 ^b
	p-value	0.000	0.000	0.000

^{A,B} means with different superscripts in the same column indicated significant difference ($p < 0.05$), A better than B. ^{a,b} means with different superscripts in the same column indicated very significant difference ($p < 0.01$), a better than b.



(a)



(b)

Figure 2. The final performances of broilers in (a) closed house - Iswandi's Farm and (b) stage slated-open side house - Rifal's Farm.

Broilers' performances each week

Broiler performances each week during five weeks of rearing in the CH and OH are presented in Table 2. Performances each week were measured for seven days of bird's development within an observed week. Analysis of

variances indicated that some performance parameters, such as BW, BWG, FCR, FER, and culling, were significantly different at $p < 0.05$ in week 1. Some of those, such as BW, BWG, FI, and depletion, were affected at $p < 0.01$ in week 2. However, the others, such as FCR, FER, mortality, and culling, were not significantly different ($p > 0.05$) in weeks 2 and 3. Except for mortality, all parameters were significantly different at $p < 0.01$ in weeks 4 and 5.

Table 2. The broiler performances each week reared in a closed house versus in a stage slatted-floor open-sided house.

Parameters	Housing type	Weeks				
		1	2	3	4	5
Body weight (g b ⁻¹)	CH	168±4.83 ^B	446±6.85 ^b	925±18.02 ^B	1636±74.40 ^a	2295±11.79 ^a
	OH	178±11.93 ^A	493±23.71 ^a	942±13.17 ^A	1481±56.93 ^b	1930±47.84 ^b
	p-value	0.028	0.000	0.025	0.000	0.000
Weekly body weight gain (g b ⁻¹ w ⁻¹)	CH	124±4.83 ^B	277±5.03 ^b	480±19.72 ^A	711±68.91 ^a	660±76.36 ^a
	OH	134±11.94 ^A	315±29.73 ^a	449±34.87 ^B	539±57.71 ^b	450±73.05 ^b
	p-value	0.028	0.001	0.024	0.000	0.000
Weekly feed intake (g b ⁻¹ w ⁻¹)	CH	138±0.29 ^b	409±0.55 ^b	726±3.61 ^a	1037±4.92 ^a	1171±3.03 ^a
	OH	160±3.94 ^a	468±8.02 ^a	669±9.46 ^b	1028±4.86 ^b	1000±2.61 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Feed conversion ratio	CH	1.12±0.04 ^A	1.48±0.03	1.51±0.06	1.47±0.14 ^a	1.80±0.20 ^a
	OH	1.21±0.11 ^B	1.50±0.16	1.50±0.12	1.93±0.21 ^b	2.29±0.44 ^b
	p-value	0.030	0.736	0.716	0.000	0.005
Feed efficiency ratio	CH	0.90±0.04 ^A	0.68±0.01	0.66±0.03	0.69±0.07 ^a	0.56±0.06 ^a
	OH	0.84±0.08 ^B	0.67±0.07	0.67±0.05	0.52±0.06 ^b	0.45±0.07 ^b
	p-value	0.038	0.947	0.614	0.000	0.002
Mortality (%)	CH	0.19±0.06 ^a	0.23±0.08	0.58±0.26	0.36±0.09 ^A	0.49±0.12 ^b
	OH	0.50±0.21 ^b	0.37±0.23	0.54±0.26	0.59±0.29 ^B	1.18±0.29 ^a
	p-value	0.000	0.095	0.718	0.028	0.000
Culling (%)	CH	0.02±0.03 ^A	0.13±0.06	0.30±0.12	0.08±0.06 ^a	0.08±0.07 ^a
	OH	0.15±0.18 ^B	0.22±0.22	0.32±0.24	0.32±0.23 ^b	0.34±0.27 ^b
	p-value	0.047	0.233	0.848	0.005	0.007
Depletion (%)	CH	0.21±0.05 ^a	0.36±0.08 ^a	0.89±0.26	0.44±0.08 ^a	0.57±0.07 ^a
	OH	0.65±0.27 ^b	0.59±0.21 ^b	0.86±0.20	0.92±0.28 ^b	1.53±0.26 ^b
	p-value	0.000	0.005	0.808	0.000	0.000

^{A,B} means with different superscripts in the same column indicated significant difference ($p < 0.05$), A better than B. ^{a,b} means with different superscripts in the same column indicated very significant difference ($p < 0.01$), a better than b.

All data on broilers' performances each week can be found in Table 2. However, some interesting parameters should be better plotted in the graph to expose the patterns of performance development from week to week from the beginning until the end of rearing. The polynomial functions were created based on the available data. In Figure 3a, it was observed that during the first three weeks, BWG was slightly better in OH. However, the result showed a better BWG in CH in which crossing curves occurred at the point of week 3. This achievement was associated with the feed intake indicated in Figure 3b. Figure 3c emphasized that birds used feed more efficiently in the OH during the first three weeks, but then after, the CH showed more efficiency in feed utilization.

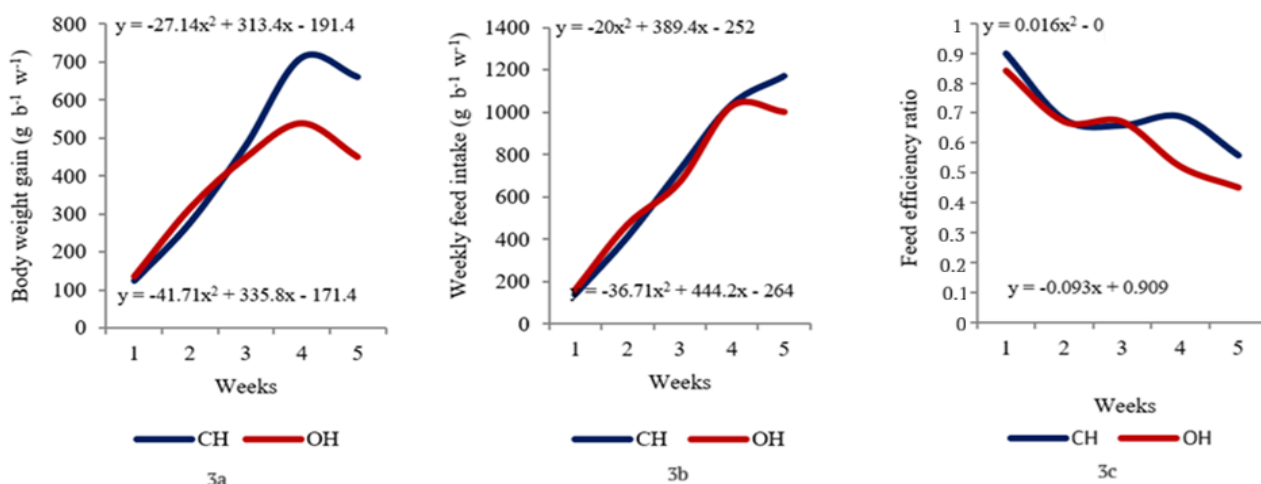


Figure 3. The patterns of body weight gain (3a), weekly feed intake (3b), and feed efficiency ratio (3c) of broilers reared in a close house versus in a stage slatted-floor open-sided house from week to week.

Performance index of broilers at market ages

The performance index (PI) of a broiler is one of the best ways to assess the success rate of producing broilers because it involves many aspects of measurement of the performances, such as BW, depletion, FCR, and harvesting age. In some countries, such as Indonesia, broilers could be offered at 3, 4, or 5 weeks of age. Therefore, the PI of broilers at these marketed ages should be calculated as presented in Table 3. The PI of broilers at 3 weeks of marketed age was very significantly higher ($p < 0.01$) in the OH, which was supported by the significantly higher ($p < 0.05$) BW/WBWG and TFI/WFI, even though very significantly higher ($p < 0.01$) depletion was found in this cage. At 4 or 5 weeks of marketed ages, a very significantly higher ($p < 0.01$) BW/WBWG and a very significantly lower ($p < 0.01$) depletion of the broilers in the CH resulted in very significantly higher ($p < 0.01$) PI in the CH than in the OH.

Table 3. Accumulating performances and performance index of broilers reared in a closed house versus in a stage slated-floor open-sided house at different marketed ages.

Parameters	Housing type	Ages of marketed broilers				
		1 week	2 weeks	3 weeks	4 weeks	5 weeks
Mortality (%)	CH	0.19±0.06 ^a	0.42±0.11 ^a	1.00±0.22 ^a	1.36±0.21 ^a	1.86±0.21 ^a
	OH	0.50±0.21 ^b	0.87±0.27 ^b	1.41±0.37 ^b	2.00±0.42 ^b	3.19±0.48 ^b
	p-value	0.000	0.000	0.008	0.000	0.000
Culling (%)	CH	0.02±0.02 ^A	0.15±0.06 ^A	0.45±0.16	0.53±0.18 ^a	0.61±0.22 ^a
	OH	0.15±0.15 ^B	0.37±0.29 ^B	0.69±0.38	1.01±0.42 ^b	1.35±0.51 ^b
	p-value	0.047	0.035	0.094	0.004	0.001
Depletion (%)	CH	0.21±0.05 ^a	0.57±0.10 ^a	1.46±0.24 ^a	1.89±0.20 ^a	2.47±0.15 ^a
	OH	0.65±0.27 ^b	1.24±0.29 ^b	2.10±0.36 ^b	3.01±0.17 ^b	4.54±0.33 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Liveability (%)	CH	99.79±0.05 ^a	99.43±0.10 ^a	98.54±0.24 ^a	98.11±0.20 ^a	97.53±0.15 ^a
	OH	99.35±0.27 ^b	98.76±0.29 ^b	97.90±0.36 ^b	96.99±0.17 ^b	95.46±0.33 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Body weight, BW (Kg b ⁻¹)	CH	0.168±0.005 ^B	0.446±0.007 ^b	0.925±0.018 ^B	1.636±0.072 ^a	2.295±0.012 ^a
	OH	0.177±0.012 ^A	0.493±0.023 ^a	0.942±0.013 ^A	1.476±0.055 ^b	1.930±0.048 ^b
	p-value	0.028	0.000	0.025	0.000	0.000
Liveability x Kg bodyweight (Kg)	CH	16.76±0.49 ^b	44.20±0.67 ^b	91.11±1.84 ^b	160.45±7.24 ^a	223.84±1.23 ^a
	OH	17.66±1.20 ^a	48.69±2.33 ^a	92.20±1.32 ^a	143.59±5.47 ^b	184.24±4.78 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Weekly body weight gain (g b ⁻¹ w ⁻¹)	CH	124±4.83 ^B	200±3.41 ^b	294±6.00 ^B	398±18.60 ^a	450±2.36 ^a
	OH	134±11.94 ^A	225±11.85 ^a	299±4.39 ^A	359±14.24 ^b	377±9.57 ^b
	p-value	0.028	0.000	0.026	0.000	0.000
Total feed intake (g b ⁻¹)	CH	138±0.29 ^b	547±0.44 ^b	1273±3.36 ^b	2311±3.07 ^b	3481±0.12 ^a
	OH	160±3.94 ^a	628±8.36 ^a	1297±3.04 ^a	2325±2.48 ^a	3325±0.76 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Weekly feed intake (g b ⁻¹ w ⁻¹)	CH	138±0.29 ^b	274±0.22 ^b	424±1.12 ^b	578±0.77 ^b	696±0.03 ^a
	OH	160±3.94 ^a	314±4.18 ^a	432±1.01 ^a	581±0.62 ^a	665±0.15 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Daily feed intake (g b ⁻¹ d ⁻¹)	CH	19.74±0.04 ^b	39.08±0.03 ^b	60.62±0.16 ^b	82.52±0.11 ^b	99.46±0.01 ^a
	OH	22.87±0.56 ^a	44.85±0.60 ^a	61.76±0.15 ^a	83.05±0.09 ^a	95.01±0.02 ^b
	p-value	0.000	0.000	0.000	0.000	0.000
Feed conversion ratio, FCR	CH	1.12±0.04 ^A	1.37±0.02	1.45±0.03	1.45±0.07 ^a	1.55±0.01 ^a
	OH	1.21±0.11 ^B	1.40±0.07	1.45±0.02	1.62±0.06 ^b	1.76±0.04 ^b
	p-value	0.030	0.164	0.910	0.000	0.000
Days x FCR	CH	7.82±0.31 ^a	19.14±0.33 ^a	30.38±0.60	40.73±1.89 ^a	54.13±0.28 ^a
	OH	8.45±0.78 ^b	19.63±1.02 ^b	30.35±0.44	45.39±1.80 ^b	61.75±1.57 ^b
	p-value	0.000	0.000	0.413	0.000	0.000
Performance index	CH	215±14.50	231±7.39 ^b	300±11.99 ^b	395±35.65 ^a	414±4.39 ^a
	OH	212±34.42	249±24.62 ^a	304±8.66 ^a	317±24.48 ^b	299±15.27 ^b
	p-value	0.059	0.000	0.000	0.000	0.000

^{A,B} means with different superscripts in the same column indicated significant difference ($p < 0.05$), A better than B. ^{a,b} means with different superscripts in the same column indicated very significant differences ($p < 0.01$), a better than b.

The FCR, depletion, and performance index are the most meaningful parameters in evaluating broilers performance in the farms. They are thought to be highly associated with the loss or gain in merchandising broilers. It can be used to help the farmers decide what the best age to send them out of the house or what the appropriate house type. The patterns of the FCR, depletion, and PI at different marketed ages of the broilers produced in the CH vs. in the OH are described in Figure 4.

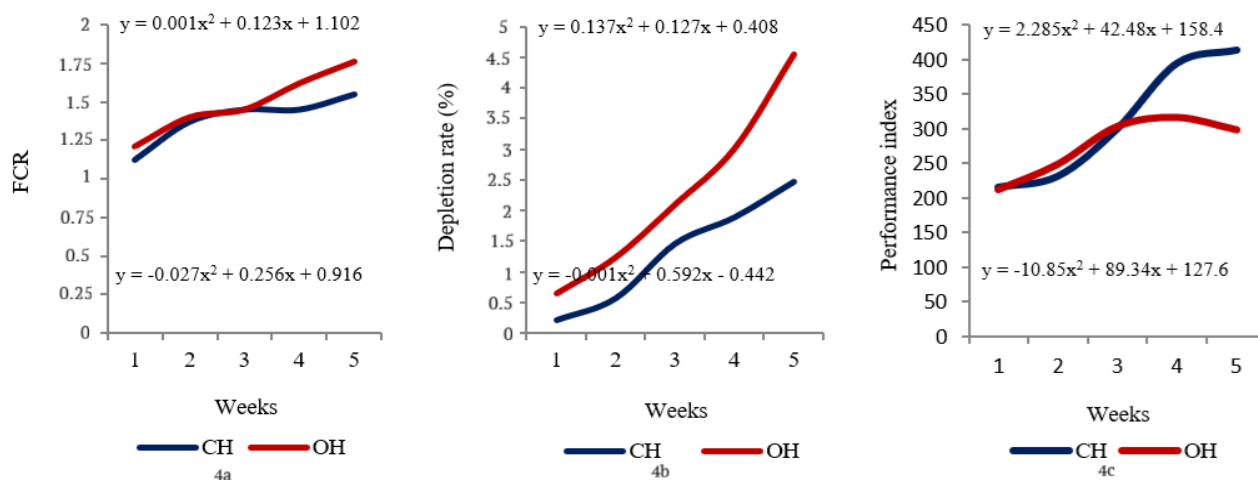


Figure 4. The pattern of feed conversion ratio (4a), depletion rate (4b), and performance index (4c) of broilers at different marketed ages produced from a closed house versus in a stage slatted-floor open-sided house.

In Figures 4a and 4b, better FCR and lower depletion did not help to result in higher PI (Figure 4c) in the CH at the marketed age of 3 weeks or less. However, over 3 weeks of age, those contributed by significantly higher BW resulted in higher PI in the CH than in the OH.

Discussion

Feed intake

Broiler's house type had significant ($p < 0.01$) effect on the total feed intake (TFI) of broilers raised for 5 weeks of age. Broilers in the CH consumed feeds higher than those in the OH. This finding agreed with Nuryati (2019), who reported that TFI in the CH vs. OH was 2.53 vs. 2.24 Kg bird⁻¹. In contrast, Muharliien et al. (2022) found that TFI in the OH was significantly higher ($p < 0.05$) than in the CH (3,507±114 vs 3,235±218 g bird⁻¹). Hamiyanti et al. (2023) found no significant difference in TFI between CH and OH (2.13±0.06 vs. 2.28±0.14 Kg bird⁻¹).

Each week, there was a converse pattern of feed intake (FI) between CH and OH. In weeks 1 and 2 (Table 2), birds in OH consumed significantly ($p < 0.01$) more feed than those in the CH. Conversely, in weeks 3, 4, and 5, the birds in CH consumed significantly higher ($p < 0.01$) feed than those in the OH. This resulted in TFI (Table 1) being higher in the OH during the starter period, but higher in CH during the grower/finisher period. During the starter, young chicks seemed more suitable to stay in the OH, so they ate more feed. Young chicks used to live in a higher thermal zone than the adults. The optimum temperature for a broiler during the first week is 31.3°C (Cassuce et al., 2013), which is similar to the environmental temperature in the tropical region during the daylight with an average of 32°C.

Nevertheless, an additional temperature is needed to meet the surrounding conditions close to the appropriate indoor environmental conditions. It was not a serious problem on whatever house type used since all cages could facilitate the brooders. The difficulty in the CH during the first two weeks might have come from overcrowded birds. High stocking density caused the birds to get feeds competitively, so they got less feed than the birds living in low stocking density. Agree with Abudabos et al. (2013), broiler chickens under high stocking density decreased feed intake slightly, reduced feeder space. However, over two weeks of age, the chick guards were removed completely, thus providing more space for up to 16.7 birds (m²)⁻¹ in the CH and 9.3 birds (m²)⁻¹ in the OH. According to Elgaber et al. (2023), there was no standard definition for broiler stocking density during rearing. The European Union (Council Directive 2007/43/EC) suggests keeping the allowed stocking density for advanced broiler chickens at 33 kg (m²)⁻¹ but raising it to 39 Kg (m²)⁻¹ if fatality is managed below a certain level and climatic parameters are suitably regulated. It is equivalent to 16-18 birds (m²)⁻¹ at the average body weight of 2 Kg bird⁻¹. Therefore, available floor space during the last phases in the CH in the recent study did not considerably upset the birds to eat.

During the grower/finisher period, the chickens need a lower environmental temperature. With an open-sided housing system, it is not easy to provide an ideal temperature closer to the best physiological body of the chickens, thus potentially causing them to undergo heat stress. To prevent this circumstance, the chickens naturally restrict their feed intake as an adaptive mechanism to minimize metabolic heat production. It is a

popular way to reduce the physiological impact of heat stress on broilers (Apalowo et al., 2024). In a closed housing system, the hot outside temperature is reduced when the air enters the house through a cooling pad, furnishing a desired temperature for the chickens. So, during the grower/finisher, they ate more feed than in the OH (Table 1). Lower floor space in the CH was not a pivotal limitation for the bird to eat rather than the requirement for a comfortable atmosphere. Since weekly feed intake was higher during the grower/finisher than the starter phase, TFI in the CH was higher than in the OH (Table 1).

Body weight and body weight gain

The average final body weight (FBW) and weekly body weight gain (WBWG) of broilers were very significantly higher in the CH than those in the OH (Table 1, 2). Most previous studies, either conducted by the method of survey or observation, reported broilers reared in the CH had higher body weight than those in the OH (Nuryati, 2019; Pakage et al., 2020; Muharliien et al., 2022). The result of a survey by Nuryati (2019) at the broilers' farms of Agricultural PPPPTK, Cianjur District, Indonesia, based on the farm's recording for 6 periods of production, found that the average FBW of broilers (unreported harvested age) was 1.43Kg bird⁻¹ in the CH and 1.38 Kg bird⁻¹ in the OH. Pakage et al. (2020) based on their survey at the plasma farms in Pangelaran, Dampit, and Bantur, Malang District, Indonesia, in partnership with PT Sinar Sarana Sentosa, Tbk reported the average FBW of broilers at 32 days of age in the CH was 1.99 Kg bird⁻¹, while in OH, it was 1.97 Kg bird⁻¹. In the recent study, the average FBW of broilers was not collected from the respondents but based on the observation at the studied farms by sampling 200 birds from each house, showing very significantly higher average FBW in the CH than in the OH (Table 1). This study was done similarly to Muharliien et al. (2022) carried out at Sumardi's Farm, Kademangan Village, Pagelaran District, Malang, Indonesia, in partnership with PT Japfa Comfeed Indonesia by sampling 120 birds from each house. They found that FBW of broilers at 35 days was 2359±210 g bird⁻¹ in CH vs. 1939±140 g bird⁻¹ in OH. Sumarno and Supartini (2022) observed broilers' performances in the CH and OH at broilers' farms in Kelurahan Rekesan, Wagir District, Malang, Indonesia. They found no significant difference in FBW between CH and OH. The results of the recent study did not agree with those found by Hamiyanti et al. (2023), who reported no significantly higher BW in the OH vs. CH at 28 days old (1567 vs. 1528). However, at 3 weeks of age, BW was significantly higher in the OH than in the CH. During the grower/finisher period, birds are faced with heat stress, causing less optimal growth than those living in the CH. Although many reports showed the FBW of broilers in the CH was higher than in the OH, the live weight varied from farm to farm.

The achievement of body weight is highly related to cumulative feed intake (Aerts et al., 2003; Orheruata et al., 2006; Abdollahi et al., 2018). Increasing feed intake in the CH led to increasing nutrient intake, thus supporting the broiler's weight (Abdollahi et al., 2018). The significant differences in BW and BWG were detected each week (Table 2). Like a feed intake, BW or BWG has a contrast curve between CH and OH. The pattern of BWG followed similarly to that of FI (Figure 3). The BW was significantly higher in the OH at 7 and 14 days old, but at 21, 28, and 35 days old, it was higher in the CH. It resulted in BW on the last day of the starter period being significantly ($p < 0.05$) higher in the OH, while at the end of the overall period, it was higher in the CH. According to Aerts et al. (2003) and Orheruata et al. (2006), the relationship between feed intake and weight gain is nonlinear. A significantly higher BW of the chickens occurred in the OH during the first three weeks. However, during the fourth week or over, higher BW appeared in the CH. Broilers in the CH have increased their BWG since the third week. The birds in the OH consumed more feed during the starting stage, so their BW increased. In contrast, the birds in the CH consumed more feed during the grower/finisher stages to enhance their BW.

Body weight continued to increase until five weeks, but the peak of BWG reached 4 weeks and then declined (Table 2, Figure 3). At 7 and 14 days, lower BW in the CH was in line with Hamiyanti et al. (2023). However, at 28 days, this study found higher BW in the CH. Lower BW in the CH of their arguments was due to the different densities accepted by the study for the starter but not for the grower/finisher period. Older chicks in the OH may have experience in feed competition. During the grower/finisher, they must eat less to prevent excessive heat production, causing lower achievement in FBW. Therefore, during this period, floor space was not as crucial as a convenient atmosphere generated by a comfortable temperature. This point was the best age to market the broilers (Table 3, Figure 4). Nevertheless, most consumers in Indonesia asked for 3 to 5-week-old broilers.

Feed conversion ratio and feed efficiency ratio

Fundamentally, feed conversion ratio (FCR) and feed efficiency ratio (FER) are similar. FCR divides FI by BWG, while FER calculates it inversely. Therefore, the lower FCR or the higher FER is the better. It is the way

to evaluate broiler performances by connecting BWG with FI. The FCR and FER of broilers reared up to 5 weeks of age in different houses had very significant differences ($p < 0.01$). Most previous studies, such as Sumarno and Supartini (2022), Pakage et al. (2020), Muharliien et al. (2022), Farida et al. (2022), and Laili et al. (2022) reported that FCR in the CH was better than in the OH, and those agreed with this study. Their findings on FCR in the CH vs. OH were 1.71 vs. 1.83 (Sumarno & Supartini, 2022), 1.38 ± 0.08 vs. 1.83 ± 0.11 (Muharliien et al., 2022), 1.60 vs. 1.77 (Pakage et al., 2020), 1.52 vs. 1.55 (Farida et al., 2022), and 1.35 vs. 1.39 (Laili et al., 2022). In contrast, Nuryati (2019), reported FCR in the OH was better than in the CH (1.62 vs. 1.78), while Hamiyanti et al. (2023) found no significant difference in FCR between the CH vs. OH (1.42 vs. 1.46).

With the exception 1st week, FCR and FER during the earlier phase seemed not affected significantly. It progressively increased in the OH in the 4th week or over (Table 2). Broilers raised for up to 5 weeks of age in the CH had better FCR and FER than those in the OH because in balancing FI, the former had very significantly higher BW than the latter (Table 1). Although, on the last day of the starter period, BW was higher in the OH, the FCR did not exhibit to be better (Table 1). It was caused by the chickens using feed inefficiently in the OH. Coming to the grower/finisher, they become very significantly poor in the FCR and FER. The rapid growth of broilers in the CH during the grower/finisher was thought not only as the increase in feed intake but also because the ambient temperature of the poultry house supported the chickens' use of feed efficiently. In contrast, the chickens in the OH have to combat heat stress, causing not only reduced feed intake but also loss of some nutrients. As a consequence, they used feed inefficiently. At high environmental temperatures, broilers consumed less feed and converted this feed less efficiently (Apalowo et al., 2024).

Aves were homeothermic animals that maintained their relatively constant body temperature regardless of the environmental temperature. The biological cooling mechanisms by the birds during hot weather were habitually panting, drinking more water, and resting to cope with the heat attack. Broilers performed better on the performances when living in a minimum variation of house temperature. According to Nawaz et al. (2021), broilers under heat stress (35°C) increase heat production (35.5%) and metabolizable energy intake (20.3%), and decrease energy retention (20.9%) and energy efficiency (32.4%). Optimum temperatures allow the chickens to convert nutrients into growth rather than using the calories for temperature regulation.

Mortality, culling, and depletion

Mortality is the number of dead birds, while culling is the number of eliminated birds. Both are considered lost birds, and a total of those is called depletion. In the recent study, the total depletion of raising broilers for up to 5 weeks was found to be higher in the OH than in the CH (Table 1), and this agreed with Sumarno and Supartini (2022), Farida et al. (2022), and Laili et al. (2022). The broilers' mortality in the OH vs. in the CH reported by them was 3.9 vs. 3.4% (Sumarno & Supartini, 2022) and 4.21 vs. 2.86% (Laili et al., 2022). These findings disagreed with Nuryati (2019) and Pakage et al. (2020), who found higher mortality in the CH than in the OH. Nuryati found a mortality of 13.07% in the CH and 7.70% in the OH. Also reported by Hamiyanti et al. (2023), although mortality in the OH was higher than in the CH (3.59 ± 0.95 vs. 1.93 ± 0.01), statistically, these were not significantly different. Higher depletion in this cage indicated that the chickens raised in the OH were less comfortable than in the CH. Total depletion in the OH was 4.54% but reduced to less than 2.47% when producing those in the CH (Table 1).

Except in week 3, higher depletion in the OH than in the CH has been found from the first week until the last week of rearing (Table 2). Laili et al. (2022) reported that mortality was higher in the CH only during the first week, which did not agree with this study. Then after, it increased progressively in the OH, which agreed with this study. Many factors affect average flock mortality, which can be classified into internal and external factors. The internal factors involve individual-independent while the external factors may include management or environment. Yerpes et al. (2020) found the internal factors significantly associated with chick mortality in the first week were breeder age, chick gender, and breed, while external factors were highly related to the type of broiler house, equipment, and season. In the recent study, the first-week mortality (FWM) was not signalled due to internal factors since they were delivered from the same breeder. External factors such as housing type were highly assumed to affect mortality, but should not be the heat stress during the first week because the chicks need higher temperatures to warm. Cassuce et al. (2013), based on their regression models, said that the environment temperature value provided greater weighing gain for the broiler chicken growth in the first week was 31.3°C. Both houses can furnish this value, mainly during the night when the temperature drops under the threshold. Nevertheless, the possible high FWM was most thought about in farm management that might not be well served in the OH. It agreed with Yassin et al. (2009),

who stated a significant difference in FWM appeared among broiler farmers due to the difference in chick management upon arrival and during the first week, which is highly related to the management of feeding, watering, housing, stocking density, and disease control.

Chicks' suffering continued to the second week, but the death gap between OH and CH became shorter and then very minor in the third week. The stronger and healthier chicks have passed the critical point and survived in their thermoneutral zone until 3 weeks old, with no significant difference in mortality found between CH and OH at weeks 2 and 3. In the OH, the chicks could defend themselves from outside reactions by the way the operator activated the curtains to cover all the shade sides. The chicks still need heat to warm their body, especially overnight. Both houses could provide this heat by the brooders. It was in line with Cassuce et al. (2013), who stated that the desired temperature bands in the second and third weeks were 25 to 31°C and 22 to 28°C, respectively. An accumulation of dead birds during the first three weeks caused an increase in very significant mortality during this period.

When the chicks grew older, the heat in their companion shortly changed to be an opponent, and this condition was uneasy to be prevented by the system of OH. There was less choice for the OH except for scrolling the curtain entirely to remove the indoor chronic heat surplus to the outdoors. Then, the house opened to an outside area, thus potentially allowing germ invasions. In the tropical region, this situation was aggravated by a hot climate that produced heat stressors. Birds under stress showed less antibody responses and were less able to phagocytize macrophages. According to Apalowo et al. (2024), broilers subjected to heat stress during the main or secondary humoral reactions revealed lower levels of total circulating antibodies and specific IgM and IgY. Hence, higher late death in the OH was highly presumed due to heat stress weakening the immune system of the birds from pathogenic dynamics. The ventilation regulation system using open curtain allowed increased air movement from outside to inside and vice versa, but the temperature may not reach the bird's requirement. In the CH, the exhaust fan inhaled outdoor air to enter the house through the cooling pad, thus lowering the indoor temperature. According to Cassuce et al. (2013), the comfort temperature bands in the fourth and fifth weeks were 20 to 25°C and 18 to 24°C, respectively. After 4 weeks of age, the depletion tended to increase in both houses, which progressively happened in the OH (Figure 4). The temperature limit for mortality in poultry houses without environmental control is 32°C (Vale et al., 2010), and above 30°C may cause high mortality (Abu-Dieyeh, 2006; Vale et al., 2010). According to Apalowo et al. (2024), temperature regulation occurs effectively when the birds are kept within a thermoneutral zone, which ranges from 21 to 28°C, allowing them to maintain a stable temperature for their internal organs. A fluctuation in the environmental temperature above the upper limits of the pleasant zone leads to heat stress in birds, which affects the overall performance of the chicken and can result in mortality.

Performance index

The PI was significantly ($p < 0.01$) affected by house type in which broilers reared in the CH had very significantly higher ($p < 0.01$) PI than those in the OH at 5 weeks of marketed age. This finding agreed with Pakage et al. (2020), who reported that the PI of broilers was 336 in the CH and 313 in the OH. Farida et al. (2022), based on their survey, found PI 389 in the CH and 358 in the OH. However, this study was not in agreement with Nuryati (2019), Sumarno and Supartini (2022), and Hamiyanti et al. (2023). Nuryati (2019) reported higher PI in the OH than in the CH (255 vs. 213), and Sumarno and Supartini (2022) said 275 IP in the OH and 267 in the CH, while Hamiyanti et al. (2023) reported no significant different IP between the CH vs. OH (369.50 vs. 363.50).

There was no significant difference in PI at week 1, but at weeks 2 and 3, it was better in the OH. Conversely, it was better in the CH at week 4 or 5 (Table 3, Figure 4). Similarly reported by Laili et al. (2022), during the first two weeks, PI was lower than standard. But, in the last phases, it increased over the standard. At week 1, broilers reared in the OH had very significantly lower ($p < 0.01$) liveability. In contrast, their BW at this week was significantly higher ($p < 0.05$) than that in the CH, while FCR was not significantly different ($p > 0.05$) between CH and OH, resulting in an equal PI between both houses (Table 3). For up to 2 and 3 weeks, although broilers in the OH had significantly lower ($p < 0.01$) liveability, their FCR was not impacted, with significantly higher BW, the PI had a significantly higher in the OH at these weeks. When the broilers were raised to 4 or 5 weeks, BW was very significantly higher ($p < 0.01$) in the CH. At these points, FCR was very significantly better ($p < 0.01$) in the CH, and their liveability was very significantly higher ($p < 0.01$), resulting in very significantly higher ($p < 0.01$) PI in the CH than in the OH.

Figure 4 shows that adverse direction occurred since week 4 when PI became visible significantly higher in the CH than in the OH. Higher depletion has reappeared in the OH since the fourth week, in which the heat

stress has been accused as the main cause. It did not only hurt the depletion, but all performance parameters, such as FI, BW, and FCR were also impacted. Therefore, raising broilers for up to 4 or 5 weeks will generate higher PI in the CH than in the OH.

Farmers may use OH to produce the broilers just for marketing at 3 weeks of age. If the chickens are marketed at 4 or 5 weeks, it will be better to keep them in the CH. For that reason, raising broilers in the CH would be a better choice for the farmers to minimize any disadvantages. According to Santoso and Sudaryani (2009), PI was categorized as follows: <300= poor, 301 to 325= fair, 326 to 350= good, 351 to 400= very good, and > 400= excellent. Based on these scores, this study found producing broilers at 3 weeks of age resulted in fair PI in both houses (300 in the CH and 304 in the OH). At the 4-week-marketed age, very good PI (395) was exhibited in the CH but fair in the OH (317), and at the 5-week-marketed age, CH performed excellent PI (414), but OH generated poor PI (299).

Conclusion

Based on this study, it can be concluded that producing broilers over three weeks of age, run by the broilers' farmers in Desa Simpang Jambe, Simpang Kramat District, North Aceh, Indonesia, in collaborating with Charoen Pokphand Jaya Farm Indonesia, under an inti-plasmas partnership model, performed better performances in the closed housing system, which indicated by higher final body weight, weight gain, feed intake, liveability, and performance index, and better feed conversion ratio and depletion rate than those in the stage slatted-floor open-sided housing system. It could be allowed for the farmers to produce broilers in the stage-slatted open-sided house for 3 weeks of marked ages. Although showing higher depletion rate and lower liveability, the other performance parameters, such as body weight, body weight gain, feed intake, and performance index in this stage were higher in the open-sided house than those in closed house. However, over these weeks, it was better to use a closed housing system.

Data availability

The data resulting from the study are included in the Results section of the article.

Acknowledgments

The authors thank Rifal's Farm and Iswandi's Farm for providing the facilities for this study. Thanks, Pokphand Jaya Farm, Medan, Indonesia, for giving us the permission to conduct the research at those farms.

References

- Abdollahi, M. R., Zaefarian, F., & Ravindran, V. (2018). Feed intake response of broilers: Impact of feed processing. *Animal Feed Science and Technology*, 237, 154-165. <https://doi.org/10.1016/j.anifeedsci.2018.01.013>
- Abudabos, A. M., Samara, E. M., Hussein, E. O. S., Al-Ghadi, M. Q., & Al-Etiyat, R. M. (2013). Impacts of stocking density on the performance and welfare of broiler chickens. *Italian Journal of Animal Science*, 12(11), 66-71. <https://doi.org/10.4081/ijas.2013.e11>
- Abu-Dieyeh, Z. H. M. (2006). Effect of chronic heat stress and long-term feed restriction on broiler performance. *International Journal of Poultry Science*, 5(2), 185-190. <https://doi.org/10.3923/ijps.2006.185.190>
- Aerts, J. M., Lippens, M., De Groote, G., Buyse, J., Decuypere, E., Vranken, E., & Berckmans, D. (2003). Recursive prediction of broiler growth response to feed intake by using a time-variant parameter estimation method. *Poultry Science*, 82(1), 40-49. <https://doi.org/10.1093/ps/82.1.40>
- Apalowo, O. O., Ekunseitan, D. A., & Fasina, Y. O. (2024). Impact of heat stress on broiler chicken production. *Poultry*, 3(2), 107-128. <https://doi.org/10.3390/poultry3020010>
- Cassuce, D. C., Tinôco, I. D. F. F., Baêta, F. C., Zolnier, S., Cecon, P. R., & Vieira, M. D. F. A. (2013). Thermal comfort temperature update for broiler chickens up to 21 days of age. *Engenharia Agrícola*, 33(1), 28-36. <https://doi.org/10.1590/S0100-69162013000100004>
- Elgaber, A. A., Mohammed, A. A. A., Mahmoud, U. T., & Darwish, M. H. A. (2023). Effect of stocking density on broilers behaviour and welfare indices. *Assiut Veterinary Medical Journal*, 69(179), 1-13. <https://doi.org/10.21608/avmj.2023.186702.1122>

- Farida, T. E., Hanafi, N. D., & Tafsir, M. (2022). Comparative study of broiler chicken performance in closed house and conventional system in North Sumatera. *IOP Conference Series: Earth and Environmental Science*, 977, 012138. <https://doi.org/10.1088/1755-1315/977/1/012138>
- Hamiyanti, A. A., Nurgiartiningsih, V. M. A., Muharli, M., & Suyadi, S. (2023). Open, semi-closed, and closed house systems during rainy season. In E. Widodo, V. D. Ton, R. Tian, N. Man, & M Mashudi (Eds.), *Proceedings of the 3rd International Conference on Environmentally Sustainable Animal Industry* (Advances in Biological Sciences Research Volume 28, pp. 411-419). Atlantis Press.
- Laili, A. R., Damayanti, R., Setiawan, B., & Hidanah, S. (2022). Comparison of broiler performance in closed house and open house systems in Trenggalek. *Journal of Applied Veterinary Science and Technology*, 3(1), 86-91. <https://doi.org/10.20473/javest.V3.I1.2022.6-11>
- Muharli, M., Sudjarwo, E., Yulianti, D. L., Hamiyanti, A. A., & Prayogi, H. S. (2022). Comparative production performance of broiler under opened house and closed house system. *Jurnal Ilmu-ilmu Peternakan*, 30(1), 86-91. <https://doi.org/10.21776/ub.jiip.2020.030.01.09>
- Nawaz, A. H., Amoah, K., Leng, Q. Y., Zheng, J. H., Zhang, W. L., & Zhang, L. (2021). Poultry response to heat stress: its physiological, metabolic, and genetic implications on meat production and quality including strategies to improve broiler production in a warming world. *Frontiers in Veterinary Science*, 8, 699081. DOI: <https://doi.org/10.3389/fvets.2021.699081>.
- Nuryati, T. (2019). Analisis performansi ayam broiler pada kandang tertutup dan kandang terbuka. *Jurnal Peternakan Nusantara*, 5(2), 77-86. <https://doi.org/10.30997/jpnu.v5i2>
- Orheruata, A. M., Vaikosen, S. E., Alufolia, G., & Okagbare, G. O. (2006). Modeling growth response of broiler chicken to feed consumption using linear data based model structure. *International Journal of Poultry Science*, 5(5), 453-456. <https://doi.org/10.3923/ijps.2006.453.456>
- Ott, R. L. (1991). *An introduction to statistical methods and data analysis*. Duxbury Press.
- Pakage, S., Hartono, B., Fanani, Z., Nugroho, B. A., Iyai, D. A., Pulungan, J. A., Ollong, A. R., & Nurhayati, D. (2020). Pengukuran performa produksi ayam pedaging pada closed house system dan open house system di Kabupaten Malang Jawa Timur Indonesia. *Jurnal Sains Peternakan Indonesia*, 15(4), 383-389. <https://doi.org/10.31186/jspi.id.15.4.383-389>
- Direktorat Pengolahan dan Pemasaran Hasil Peternakan. (2017). *Buku saku panduan kemitraan usaha peternakan*. Direktorat Jenderal Peternakan dan Kesehatan Hewan.
- Santoso, H., & Sudaryani, T. (2009). *Pembesaran ayam pedaging di kandang panggung*. Penebar Swadaya Press.
- Sumarno, Y. W., & Supartini, N. (2022). Study of broiler production performance in closed house and open house cage systems. *Jurnal Agriekstensi*, 21(1), 42-50.
- Vale, M. M., Moura, D. J., Nääs, I. A., & Pereira, D. F. (2010). Characterization of heat waves affecting mortality rates of broilers between 29 days and market age. *Brazilian Journal of Poultry Science*, 12(4), 279-285.
- Yassin, H., Velthuis, A. G. J., Boerjan, M., & van Riel, J. (2009). Field study on broilers' first-week mortality. *Poultry Science*, 88(4), 798-804. <https://doi.org/10.3382/ps.2008-00292>
- Yerpes, M., Llonch, P., & Manteca, X. (2020). Factors associated with cumulative first-week mortality in broiler chicks. *Animals*, 10(2), 310. <https://doi.org/10.3390/ani10020310>