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Macroclimate at Different Altitudes on Changes in Microclimates in a Closed House

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ABSTRACT

This study was conducted to determine and analyze the effect of differences in altitude levels on the macroclimate and microclimate in a closed house. This research was carried out at a closed house in the lowland, medium land, and highland with a length of 120 m and a width of 12 m. Observed data were made for 28 days at three times. Parameters observed include temperature, wind speed, humidity, and solar radiation. Macroclimate contribution to the microclimate was calculated based on the relationship's strength using correlation analysis and forming a regression equation. The results showed that the gift of macroclimate components to microclimate conditions in the form of temperature and humidity was more significant in the cages in the lowland and highland. In contrast, the contribution to wind speed was minimal. The predictor of air humidity in a cage in the lowland during the brooding phase was influenced by temperature, humidity, wind speed, and solar radiation; during the finisher phase, the temperature and humidity in the cage in the lowland were influenced by temperature, humidity, and solar radiation. This study concluded that the contribution of macroclimate factors to microclimate conditions in the brooding phase is more significant in the cage in the lowland. In comparison, in the finisher phase, the contribution is more important in the lowland and medium land.

Key words: closed house, altitude, macroclimate, microclimate

INTRODUCTION

Indonesia including into a tropical country that has high temperatures and humidity. High temperature and humidity cause more minor conditions for maintaining animal livestock, especially broiler chickens. Using a closed cage house is one solution to create an environment for proper maintenance for broiler chickens. *A closed house* used as a model cage maintenance aims to create a condition microclimate that can be controlled. Condition macroclimate is important for noticed during maintenance because if condition macroclimate extreme scorching and sudden heat rain or on the contrary will affect the condition microclimate cage.

Condition microclimate takes effect by direct to chicken so that influence condition physiological body as well as productivity from chicken. A comfortable temperature for broiler chickens aged one day 29 - 32°C, aged three days 27 - 30°C, aged six days 25 - 28°C, aged nine days 25 - 27°C, and aged above 12 days 24 - 26°C (Shadow et al., 2016). Humidity cages for broiler chickens range between 50 – 70% (Fahrurozi *et al.*, 2014). Speed wind ideal cage for broiler chicken range between 1.80 – 2.00 m/s (Syamsuryadi *et al.*, 2017). Conditioning the microclimate above the limit comfortable will make broiler chicken becomes not comfortable enough and trigger stress.

Factor weather and altitude influence the condition in the cage (microclimate) (Tamzil, 2014). plain low is an area with a height of 0 - 400 m above sea level, while the plains are at an altitude of 400-700 m above sea level, and the highlands are located at an altitude of >700 m above sea level (Istiawan and Kastono, 2019). Height different places affect the macroclimate and impact the conditioning environment inside the cage to provide a comfort zone for broilers (Ozkan et al., 2010).

Study this held with destination for now and analyze influence difference height plains to macroclimate and microclimate in the cage *closed house*. The hypothesis study is that different height plains affect the condition macroclimate during broiler rearing around the cage, and other conditions macroclimate affect the condition microclimate inside the cage.

MATERIALS AND METHODS

Materials used are *closed-house* cages of the same size, each cage length of 120 m, width 12 m, and capacity of 22,000 birds, located in low, medium, and highland areas. Kestrel ™ is used for measuring temperature, humidity, wind speed, and black globe temperature for measuring solar radiation. Measurement macroclimate and microclimate were conducted for 28 days at three times (07.00, 12.00, and 17.00 WIB). Cage *closed-house* shared into four pens, and measurement microclimate carried out in each cell on each enclosure, inside each pen is measured at 5 points use a kestrel with putting tool 50 cm high from floor. Measurement macroclimate was performed at 4 points on the front, back, and side's right and left outside the cage, with putting kestrel as high as 100 cm from the floor. Radiation sun is measured with measure temperature on the black tool *globe* placed on the side adjacent right or left cage caught ray sun by straight away. Experimental parameters are factor climate outside the cage (temperature, humidity, speed wind, and radiation sun) and microclimate (temperature, humidity, and speed wind). Average condition data macroclimate and microclimate are presented in Tables 1 and 2.

Table 1. Average macroclimate data on the three plain

Parameter	plain	For 28 days
Temperature (ºC)	Low	31.6
	Currently	27.9
	Tall	28.1
Humidity air (%)	Low	65.5
	Currently	76.6
	Tall	68.8
Speed wind (m/s)	Low	1.1
	Currently	0.5
	Tall	0.4
Radiation sun (W/m^2)	Low	523
	Currently	465.5
	Tall	475

Connection Among condition macroclimate with microclimate analyzed use analysis correlation. Parameters with the value of r > 0.5 are considered to have contributed strong enough until very strong used for shape equality regression. In research, this formula analysis multiple linear regression (Ratnasari et al., 2015), namely:

$$\mathbf{Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4}$$

Description :
Y = condition microclimate (dependent)
a = constant
b = coefficient regression
X_1 = temperature macroclimate (independent)
X_2 = humidity air macroclimate (independent)
X_3 = speed wind macroclimate (independent)
X_4 = radiation sun (independent)

Table 2. Average of microclimate and temperature data effective on a third plain

Parameter	plain	For 28 Days
Temperature (ºC)	Low	32
	Currently	28
	Tall	28
Humidity air (%)	Low	60
	Currently	77
	Tall	73
Speed wind (m/s)	Low	1.8
	Currently	1.7
	Tall	1
Temperature Effective (ºC)	Low	23
	Currently	22
	Tall	25

RESULTS AND DISCUSSION

Correlation results among component macroclimate to condition microclimate cage *closed-house* broiler chicken on the plain different presented in Table 3 – 8.

Temperature Microclimate

Condition microclimate on the plains low has temperature 32℃ with speed 1.8 m/s wind and humidity 60%, while on the tables currently have temperature 28℃ with speed wind 1.7 m/s and humidity 77%. On plains, tall has a temperature of 28℃, speed wind of one m/s, and humidity of 73%. Condition microclimate on the third plains that have temperature effect on the table's low 23℃, plain medium 22℃, and plain 25℃ high.

Analysis result correlation among component macroclimate to condition temperature microclimate in brooding phase is shown in Table 3. Correlation component macroclimate in the form of temperature showing contribution strong enough to temperature microclimate on the plains medium and high which have an impact on increasing temperature cage, temporary radiation sun no contribute to the third plains. Humidity macroclimate contributes strong enough to temperature microclimate on the plains medium and high, while speed wind macroclimate no contribute to temperature microclimate. Inside temperature cage experience enhancement, so that target temperature is exceeded then the temperature sensor will give the order to control panel for increase activity *exhaust fan* to get lower temperature, condition the could be achieved if ability *exhaust fan* equivalent with eliminating temperature with capacity maximum from *fans*. Enhancement temperature inside the cage that doesn't could be compensated by *the exhaust fan* will also cause an enhancement temperature body of the chicken. Research results Baracho et al. (2011) increase temperature air around the impact on growing temperature body chicken, for guard temperature body keep it ideal then the chicken will throw away excessive heat to the environment. Disposal of hot body chicken through radiation, convection, conduction, and evaporation. Increased drinking water consumption is one method of removing too much hot from body chicken. Bruno et al. (2011) show that an enhancement temperature of as much as 9℃ causes an enhancement in drinking water consumption of 3.87 ml. Enhancement of drinking water consumption will also influence the decrease in consumption feed, so that increase low body weight

The sun's radiation increases at certain hours, especially at noon at 12.00; it's hot delivered through the air by radiation to building cage or part roof cage. According to Yani et al. (2014), at noon at 13.00, the peak intensity accompanying sun with enhancement temperature is a condition. Speed wind macroclimate on the plains is low and high, contributing to increasing temperature microclimate inside the cage, although his contribution is weak.

Table 3. Correlation among component macroclimate to temperature microclimate in the brooding phase

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (ºC)	0.230**	0.587**	0.484**
Speed Wind (m/s)	0.031	-0.088**	0.208**
Humidity (%)	-0.213**	-0.670**	-0.574**
Radiation Sun (W/m ^{2})	0.160**	0.312**	0.340**

Description : * * : Correlation significant at 1% level

Change condition speed wind and humidity macroclimate give effect on change condition microclimate. Study Qurniawan *et al.* (2016) shows the taller humidify the air in a region so temperature air the higher because the process of evaporation of water is running slow. That related to high temperature inside the cage will increase drinking water consumption from chicken, so excreta issued contain a lot of water that makes the litter damper. Speed rising wind generated from the performance *exhaust fan* that plays a role suck air from in cage, so hot inside cage no accumulate and cause the temperature in cage decreased. According to Amijaya *et al.* (2018), wind speed in a *closed house* significantly increases from the inlet to the destination outlet as the distribution process oxygen and displacement hot as effort throw away hot from in cage.

Analysis result correlation among component macroclimate to condition temperature microclimate in the finisher phase is shown in Table 4.

Table 4. Correlation among component macroclimate to temperature microclimate in the finisher phase.

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (ºC)	0.884**	0.881**	0.625**
Speed Wind (m/s)	0.248**	-0.053*	0.209**
Humidity (%)	-0.831**	-0.623**	-0.509**
Radiation Sun (W/m ^{2})	0.783**	0.698**	0.683**

Description : * : Correlation significant at 5% level, **: Correlation significant at 1% level

Macroclimate temperature t and radiation the sun in the third plains contribute very strongly to temperature microclimate, while speed wind contributes weakly to temperature microclimate. Speed wind macroclimate potential brings temperature hot from the outside cage to enter, which impacts increasing temperature microclimate inside a cage.

Enhancement temperature inside the cage will cause temperature perceived effectiveness the chickens to come to increasing impact *heat stress* consequence failure thermoregulation and improve expenditure hot. Menu ut Tamzil (2014) efforts can resolve *heat stress* that is manipulated temperature environment during maintenance with technology cage. Increased drinking water consumption is one method of disposing of too much body chicken. Research results by Tamzil *et al.* (2013) show that chickens exposed to heat stress *for* 1-hour increase drinking water consumption by as much as 0.57 ml/head/minute. Radiation from the sun at noon also causes the control panel's target temperature to be too much, so compensated with enhancement work *exhaust fan* with destination lower and maintain the target temperature. According to Endraswati *et al.* (2019), the sun is one factor in temperature microclimate. Humidity macroclimate on the character of the third plains harmful to temperature cage, it means enhancement humidity macroclimate cause drop temperature inside the cage. That thing is caused due to the process of evaporation of water in a less than optimal environment; when air with content still water vapor enters the cage will influence the dropping temperature inside the cage. In research, Qurniawan *et al.* (2016) found more tall humidity air in a region, so the air temperature is low.

Microclimate Air Humidity

The contribution factor macroclimate to humidity in the brooding phase is presented in Table 5. Components macroclimate that is humidity and temperature contribute strongly enough until very strong to humidity microclimate on the third plains (Demak, Gunungpati, and Ampel). In contrast, radiation sun contributes strongly enough only on plains low. Speed wind no contributes significantly to humidity microclimate. The contribution of humidity macroclimate to the character of the third plains is positive to humidity air microclimate. Meanwhile, temperature and radiation are negative with humidity air microclimate in third plains.

Table 5. Correlation among component macroclimate to humidity microclimate in the brooding phase.

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (ºC)	-0.852**	-0.505**	-0.611**
Speed Wind (m/s)	0.017	0.131**	-0.292**
Humidity (%)	0.905**	0.675**	0.735**
Radiation Sun (W/m ^{2})	-0.663**	-0.320**	-0.442**

Description : ** : Correlation significant at 1% level

Radiation high sun effect on increasing outside temperature cage, moment temperature macroclimate increase and get carried away enter to in cage cause enhancement temperature inside the cage. According to Yani *et al.* (2014), when the temperature environment enters the cage and more low than the surrounding, it will lower the temperature inside the cage and vice versa. Temperature high air will speed up the evaporation process so that water vapor in the environment is low. Speed wind in the environment helps with the entry process of air to cage pass *pads* or wet bearings, resulting in the temperature of incoming air into the cage decreasing, accompanied by water vapor that goes carried away enter so that humidity in the cage increase. Study Endraswati *et al.* (2019) shows active *water sprinkled* on a *cooling pad* moment air enters the cage causes the temperature to decrease and increase the humidity inside. According to Fadholi (2013), the mood in a place is affected by temperature, air environment, pressure air, and wind speed. The contribution factor macroclimate to humidity air in the finisher phase is presented in Table 6.

Table 6. Correlation Among component macroclimate to humidity microclimate in the finisher phase.

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (ºC)	-0.699**	-0.689**	-0.541**
Speed Wind (m/s)	-0.157**	0.016	-0.249**
Humidity (%)	0.840**	0.830**	0.652**
Radiation Sun (W/m ^{2})	-0.707**	-0.612**	-0.579**

Description : ** : Correlation significant at 1% level

Temperature, humidity macroclimate, and solar radiation in the third plains (Demak, Gunungpati, and Ampel) contributed very strongly to humidity air microclimate. Still, the contribution of temperature and radiation to the sun in the character of the third plains is negative, meaning every enhancement of temperature macroclimate and radiation sun will cause a drop in humidity air microclimate.

Radiation high sun influence outside temperature cage increase and enter into the cage through the *cooling pad* so that moment influence enhancement temperature inside the cage, the *control panel* will respond with enhancement speed wind and automatic *water sprayer* on *cooling pad* light up for cool temperature. The activity *water sprayer* causes the humidity of the air inside the cage to increase. According to Endraswati *et al.* (2019), activation *water sprinkle* carried out by the control panel automatic moment temperature in the cage increase work *exhaust fan* that causes the temperature in cage decrease and increases the humidity inside the cage. Speed wind contributes negatively to humidity air microclimate, though connection correlation is weak, so the enhancement of speed wind macroclimate cause humidity air inside the cage to decrease. Olivia *et al.* (2015) components macroclimate, especially on noonday in the form of temperature, radiation sun and speed wind relatively tall so that impact on the increasing temperature in the cage.

Speed Wind Microclimate

The correlation among component macroclimate to speed wind the microclimate in the brooding phase is presented in Table 7. Elements of macroclimate in the form of temperature, speed wind, humidity, and radiation sun contribute weakly to speed wind microclimate on the third plains (Demak, Gunungpati, and Ampel). The relationship is significantly positively or negatively correlated (r>0.5).

Table 7. Correlation among component macroclimate to speed wind microclimate in the brooding phase.

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (°C)	0.167**	0.074**	0.022
Speed Wind (m/s)	0.182**	0.472**	0.158**
Humidity (%)	-0.064**	0.135**	0.200**
Radiation Sun (W/m^2)	0.129**	-0.188**	-0.002

Description : * * : Correlation significant at 1% level

The temperature of the air outside the cage increase and enter the cage. Pass *cooling pad* will respond by the connected sensor with the control panel, increasing the speed of wind inside the cage to resolve temperature enhancement inside the cage. Research results in Fidaros *et al.* (2018) show that enhancement use of fan with destination increases speed wind, which makes it worse condition microclimate cage because condition convenience thermal not only described by temperature but also by speed air. Using three fans wind, because enhancement limited temperature with average enhancement speed. Humidity macroclimate on the plains medium and high contribute to increasing speed wind inside the cage; on the other hand, low enhancement humidity macroclimate cause drop speed wind. Humidity air rising and incoming macroclimate into the cage causes a drop in temperature and enhances humidity microclimate.

Contribution radiation sun character negative to speed wind microclimate on the plains medium and plain high, while on the ground low gives a contribution to increasing speed wind inside cage although his contribution was weak. Radiation high sun influence enhancement outside temperature cage and enter to in cage through *cooling pad* so that moment influence enhancement temperature inside the cage will be balanced with enhancement speed wind for guard temperature inside cage permanent stable, according to Kic (2016) radiation the sun all around cage impact on comfort thermal in a cage and raise the temperature the air in it. According to Gad *et al.* (2020), the sun's radiation gradually increases until it reaches the highest score at 1 pm and affects the enhancement temperature macroclimate until it reaches the highest at 1 pm. The correlation among component macroclimate to speed wind the microclimate in the finisher phase is presented in Table 8.

Table 8. Correlation among component macroclimate to speed wind microclimate in the finisher phase.

Parameter	Plain Low	Plain Currently	Plain Tall
Temperature (ºC)	0.058*	0.197**	0.192**
Speed Wind (m/s)	-0.125**	0.019	0.077**
Humidity (%)	-0.031	-0.081**	-0.147**
Radiation Sun (W/m ^{2})	0.008	0.228**	0.103**

Description : * : Correlation significant at 5% level, **: Correlation significant at 1% level

Correlation Among component macroclimate in the form of temperature, speed wind, and radiation sun no contribution to speeding wind microclimate happened on the third plains (Demak, Gunungpati, and Ampel).

Radiation high sun influence outside temperature cage increase and enter into the cage through the *cooling pad,* so that moment influence enhancement temperature inside cage balanced with enhancement speed wind inside cage aim for lower temperature and distribute from the part front until behind cage, according to Fidaros *et al.* (2018) upgrade use amount operating fan with destination increase speed wind cause enhancement limited temperature. Endraswati *et al.* (2019) also confirm that activity *exhaust fans* for lower or guard temperature stay at target temperature during ability equivalent *exhaust fan* with eliminating temperature with maximum capacity *fans*.

Humidity air macroclimate character negative to speed wind microclimate, so enhancing humidity macroclimate causes drop speed wind microclimate. Humidity high air cause a drop in temperature inside a cage, so the moment the temperature goes down control panel will lower the work *exhaust fan*, causing the speed of wind inside the cage Becomes down. Olivia *et al.* (2015) principle work from an *exhaust fan* that is guard temperature cage permanently stable with method increase or lower work *exhaust fans*. Kic (2016) also confirmed that temperature influences air humidity, with the method of quieter work *exhaust fan* for balance speed wind with destination arranged temperature and humidity inside a cage. Change speed wind microclimate inside third cage plains, not easily affected by factors macroclimate.

Equality Regression

The value of determination in the brooding phase is presented in Table 9. Component humidity air macroclimate influence temperature microclimate on the plains medium and high, while radiation sun influence temperature microclimate on the plains low and high. Radiation from the sun on the tables currently does not much influence enhancement temperature inside the cage; I think the caused level intensity radiation low sun because it has already entered the season of rain. The results of Hamdi's research (2014) show that changing an area's climate will cause changes in the duration of irradiation sun during the day and the size intensity sun consequence of blocked clouds thick.

Table 9. Equation Regression Factor Influential macroclimate to Microclimate in the Brooding Phase.

Region	Microclimate Parameters (Y)	Equality Regression	R2
Plain low	Temperature (ºC)	11.475+1.048X1–0.024X4	0.058
	Humidity (%)	20.028+0.788X2–3.405X3+0.021X4–0.424X1	0.844
	Speed Wind (m/s)	-11.466+0.411X3+0.001X4+0.048X2+0.259X1	0.139
Plain currently	Temperature (ºC)	43,510–0.184X2–0.626X3	0.470
	Humidity (%)	-42.145+0.982X2+1,415X1+1.702X3	0.526
	Speed Wind (m/s)	-18.325+0.813X3+0.116X2+0.356X1	0.347
Plain tall	Temperature (ºC)	45.232–0.152X2–0.008X4	0.336
	Humidity (%)	-11.641+0.831X2+0.042X4–1.863X3	0.550
	Speed Wind (m/s)	-7.145+0.045X2+0.103X1+0.464X3+0.003X4	0.210

Description : Y : Condition microclimate , X_1 : Temperature macroclimate , X_2 : Humidity air macroclimate , X_3 : Speed wind macroclimate , X_4 : Radiation sun , R^2 : Coefficient determinant

Following the study of Widhiyanuriyawan *et al.* (2013), the radiation sun fluctuates moment the rain season, and the low sun shows that the sun closes clouds thick or cloudy. Condition humidity air microclimate in third plains (Demak, Gunungpati, and Ampel) have score determination strong, influenced component macroclimate that is humidity air and speeds wind. Humidity outside the high cage will bring water vapor together with air entering the cage and affect the moisture inside the cage. According to Fadholi (2013), the humidity of air in the environment describes the level of water vapor inside air affected by the temperature of the air environment, the pressure of air, and wind speed. Difference component composing equation on the plains low and high are also influenced by components radiation the sun, while on the plains currently no affected by component radiation sun but component temperature macroclimate. Height plains from the sea's surface will also influence the big radiation sun in place, affecting temperature and humidity macroclimate. According to Hamdi (2014), the more tall something the area, the short time of irradiation and radiation sun, and the more it decreases. Speed wind microclimate describes score determination strong enough to component macroclimate that is temperature, humidity, and speed wind, meanwhile for component radiation sun only take effect to speed wind microclimate on the plains low and plain high. The value of determination in the finisher phase is presented in Table 10.

Table 10. Equation Regression Factor Influential macroclimate to Microclimate in the Finisher Phase.

Region	Microclimate Parameters (Y)	Equality Regression	R2
Plain low	Temperature (ºC)	17.083+0.582X1–0.061X2	0.799
	Humidity (%)	4.450+0.895X2+0.711X1–0.034X4	0.713
	Speed Wind (m/s)	2.308–0.402X3+0.113X1–0.006X4	0.040
Plain currently	Temperature (ºC)	7.276+0.736X1	0.776
	Humidity (%)	54.950+0.651X2–0.033X4–0.467X1+0.703X3	0.718
	Speed Wind (m/s)	-5.642+0.010X4+0.019X2+0.068X1+0.108X3	0.065
Plain tall	Temperature (ºC)	19.612+0.027X4–0.054X2	0.520
	Humidity (%)	25,390+0.768X2–0.127X4+1,745X1+3,757X3	0.587
	Speed Wind (m/s)	0.407+0.061X1–0.001X4	0.039

Description : Y : Condition microclimate , X_1 : Temperature macroclimate , X_2 : Humidity air macroclimate , X_3 : Speed wind macroclimate , X_4 : Radiation sun , R^2 : Coefficient determinant

Component macroclimate in the form of temperature, humidity, and radiation sun influence humidity microclimate on the third plains, but on plains medium and high there is component speed wind macroclimate which also provides influence increase in humidity because worth positive in the formed equation. Speed wind microclimate on the third plains has weak score determination to component macroclimate in the form of temperature and radiation the sun, while on the plains is also influenced by components humidity and speed wind macroclimate while low affected by temperature macroclimate.

Influence temperature and influential humidity macroclimate on the temperature inside cage caused by humidity macroclimate will influence temperature air because the existence of a process of evaporation of water in the environment, In research by Qurniawan *et al.* (2016) more tall level humidity in a place so cause temperature air in place the low.

CONCLUSION

Contribution factor macroclimate to condition microclimate in the form of temperature and humidity during brooder period is bigger happened to the cage on the plains medium and high, while contribution temperature and humidity macroclimate in the finisher period are over significant happened to the cage on the plains low and medium. Speed wind macroclimate his contribution weak in third plains. Based on the thing, the cage on the plains medium and high on the starter phase more easily experience change consequence contribution macroclimate, while in the finisher phase, the cage is in the plains low and plains medium easy experience change consequence contribution macroclimate. The placement cage on the ground height (Ampel) of the three plains is more suitable than the second plain because the contribution factor macroclimate to microclimate his contribution weak.

REFERENCES

Amijaya, D. T., A. Yani dan Rukmiasih. 2018. Performa ayam ras petelur pada letak cage berbeda dalam sistem closed house di Global Buwana Farm. J. Ilmu Produksi dan Teknologi Hasil Pertanian. 6 (3): 98 – 103.

Baracho, M. S., I. A. Naas, G. R. Nascimento, J. A. Cassiano dan K. R. Oliveira. 2011. Surface temperature distribution in broiler houses. J. Poult. Sci. 13 (3): 177 – 182.

Bruno, L. D. G., A. Maiorka, M. Macari, R. L. Furlan dan P. E. N. Givisiez. 2011. Water intake behavior of broiler chickens exposed to heat stress and drinking from bell or and nipple drinkers. J. Poult. Sci. 13 (1): 147 – 152.

Endraswati, A., L. D. Mahfudz dan T. A. Sarjana. 2019. Kontribusi faktor klimat di luar kandang terhadap perubahan mikroklimat closed house dengan Panjang berbeda pada periode brooder di musim kemarau. J. Agipet. 19 (1): 59 – 67.

Fachrurozi, N., S. Tantalo dam P. E. Santosa. 2014. Pengaruh pemberian kunyit dan temulawak melalui air minum terhadap gambaran darah pada broiler. J. Ilmiah Peternakan Terpadu. 2 (1): 39 – 46.

Fadholi, A. 2013. Pemanfaatan suhu udara dan kelembaban udara dalam persamaan regresi untuk simulasi prediksi total hujan bulanan di Pangkalpinang. J. Cauchy. 3 (1): 1 – 9.

Fidaros, D., C. Baxevanou, T. Bartzanas dan C. Kittas. 2018. Numerical study of mechanically ventilated broiler house equipped with evaporative pads. Computers and Electronics in Agriculture. 149: 101 – 109.

Gad, S., M. A. El-Shazly, K. I. Wasfy dan A. Awny. 2020. Utilization of solar energy and climate control systems for enhanching poultry houses productivity. Renewable Energy: 278 – 289.

Hamdi, S. 2014. Mengenal lama penyinaran matahari sebagai salah satu parameter klimatologi. Berita Dirgantara. 15 (1): 7 – 16.

Istiawan dan Kastono. 2018. Pengaruh ketinggian tempat tumbuh terhadap hasil dan kualitas minyak cengkih (*syzygium aromaticum* (l.) merr. & perry.) di Kecamatan Samigaluh, Kulon Progo. Vegetalika. 8 (1): 27 – 41.

Kic. P., L. Ruzak, Z. Levinka, L. Lita dan I. Gardianova. 2012. Pollution of indoor environment in poultry housing. In: 11th International Scientific Conference Engineering for Rural Development. Latvia University of Agriculture Jelgava. 480 – 483.

Olivia, M., M. Hartono dan V. Wanniatie. 2015. Pengaruh jenis bahan litter terhadap gambaran darah broiler yang dipelihara di closed house. J. Ilmiah Peternakan Terpadu. 3 (1): 23 – 28.

Ozkan, S., C. Takma, S. Yahav, B. Sogut, L. Turkmut, H. Erturun dan A. Cahaner. 2010. The effects of feed restriction and ambient temperature on growth and ascites mortality of broilers reared at high altitude. Poultry Science. 89 (5): 974 – 985.

Qurniawan, A., I. I. Arief dan R. Afnan. 2016. Performans produksi ayam pedaging pada lingkungan pemeliharaan dengan ketinggian yang berbeda di Sulawesi Selatan. J. Veteriner. 17 (4): 622 – 633.

Ratnasari, R., W. Sarengat dan A. Setiadi. 2015. Analisis pendapatan peternaka ayam broiler pada sistem kemitraan di kecamatan Gunung Payi Jkota Semarang. J. Animal Agriculture. 4 (1): 47 – 53.

Syamsuryadi, B., R. Afnan, I. I. Arief dan D. R. Ekastuti. 2017. Ayam pedaging jantan yang dipelihara di dataran tinggi Sulawesi Selatan produktivitasnya lebih tinggi. J. Veteriner. 18 (1): 160 – 166.

Tamzil, M. H., R. R. Noor, P. S. Hardjosworo, W. Manalu dan C. Sumantri. 2013. Acute heat stress responses of three lines of chickens with different heat shock protein (HSP)-70 genotypes. Int. J. Poult. Sci. 12 (5): 264 – 272.

Tamzil, M. H. 2014. Stres panas pada unggas: metabolisme, akibat dan upaya penanggulangannya. Wartazoa. 24 (2): 57 – 66

Widhiyanuriyawan, D. N. Hamidi dan Wijono. 2013. Karakteristik produksi browns gas dengan menggunakan tenaga matahari. J. Rekayasa Mesin. 4 (1): 79 – 84.

Yani, A., H. Suhardiyanto, Erizal dan B. P. Purwanto. 2014. Analysis of air tempertaure distribution in a *closed house* for broiler in wet tropical climate. Media Peternakan. 37 (2): 87 – 94.