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MODIFIED RE-CIRCULATING COOLING SYSTEM FOR LOW COST POULTRY HOUSING

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Abstract

There is a widespread coping mechanism for climate change adaptations and mitigations nowadays. The extreme high temperatures experienced in the country resulted to higher mortality rate of broilers due to heat stress which led to the design of a re-circulating water conductive floor system for broiler production. An experimental set-up for cooling system was established with 2 treatments: the conventional poultry housing (T_1) and the modified poultry housing (T_2) that used re-circulating cold water conductive floor system to supply the broilers with the needed cooling effect. There were 3 replications for all treatments and each occupied an area of 2 m^2, and each filled with 16 heads of chicks reared for 28 days. The re-circulating cooling system brought about an average survival rate of 99% and a highly significant average weight of birds of 1.27 kg. The conductive flooring system was computed to be economically viable and can result to an additional profit of Php 8,616.25 for broiler raisers. Based on the results of the study, the system is recommended to be tested in a commercial scale to verify its economic viability.

Keywords: recirculating cooling system, poultry house modification, low cost

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Introduction

Broiler chicken is part of Filipino cuisine because of its availability. It is an integral part of Filipino households since its meat is an important source of protein. In fact, as of 2012, Filipinos' per capita consumption of chicken meat is 8.077 kg/year. In Bulacan, the per capita consumption is even higher, with 14.682 kg/year. It could be due to high broiler production in the province which contributed an average of 8% to the broiler production (Figure 1) in the Philippines (BAS, 2014). It could mean that chicken meat is readily available in the area or maybe due of its good characteristics in terms of meat's nutritive value since compared to pork (180 calories) and to beef (179 calories), per 100 g of meat, a person can only get 162 calories from chicken meat. Whatever the reason, broiler production is booming in Bulacan.

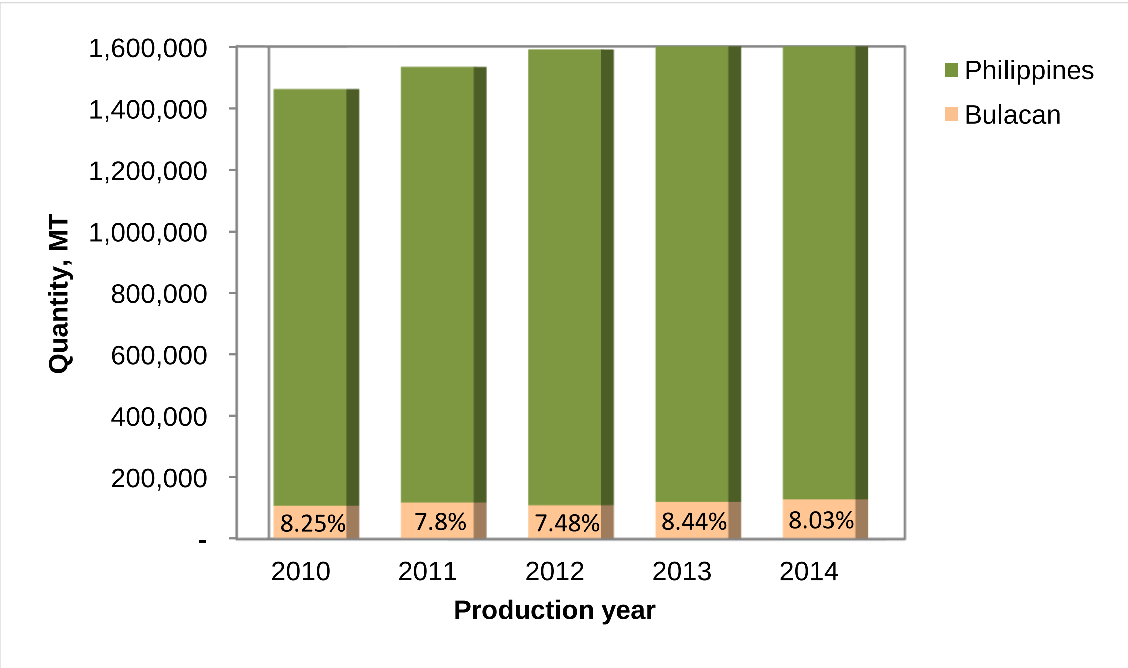

Figure 1. Broiler production in the country.

The problem in broiler production is that chicken are prone to heat stress especially during the summer when temperature is high and relative humidity is wet. Chicken does not have sweat glands so it cannot cool off by perspiring. In response to heat stress, chicken increases its respiration rate and blood flow towards the skin is enhanced (Minton, 1994). This is one of the factors that there is decrease in weight gain (de Souza et al., 2016), in consequence, chicken meat production will also decrease and farmers' income may suffer.

Environmental control or poultry housing modification is a good start in reducing the problem of heat stress. By constructing the poultry house with enough ventilation to allow good air exchange, the temperature will drop. But during the extreme high temperature especially now that the world is experiencing the effects of climate change, evaporative cooling is not enough to help decrease the inside temperature. Philippines' normal temperature ranges from 20-32°C (World Weather and Climate Information, 2015) and even went higher during summer times. The hottest months are April and May (World Bank, 2015).

There are many studies concerning poultry housing modifications in order to lower the temperature but usually uses evaporative cooling systems (Wolfenson et.al., 2001; Abdalla and Abdalla, 2006; Al-Fataftah & Abdelqader, 2013), ventilation modification (SMEDA, 2010) and poultry housing management (Gutierrez, Min and Chang, 2009) like chilled drinking water. During the extreme high temperature, evaporative cooling is enough to help decrease the inside temperature as much as 5.4°C (Al-Fataftah & Abdelqader, 2013), or 1-1.5°C as studied by Wolfenson, *et al*. (2001). By constructing the poultry house with enough ventilation to allow good air exchange, the temperature will drop by 1.0-1.5°C (SMEDA, 2010). With these advantages, it can be noted that evaporative cooling used water and will just humidify more the surrounding environment making it unadvisable in Philippine condition.

The problems of the various types of poultry housing are different from those in cool and temperate climates with the tropical country (Smith, 1981) like Philippines. The high dry-bulb temperatures with high humidity experienced in the country need to be combated, so a better selection of method must be used to achieve control of the indoor climate. Evaporative cooling will just increase further the relative humidity since water evaporated will just humidify more the surrounding environment. Hence, the proposed recirculating cooling system.

The main concept is about heat transfer through conduction using water as refrigerant in a simple cooling system in a modified poultry house for broiler production. Just like humans, broilers are warm blooded animals. When a human wants to cool off, aside from perspiration, cold water is placed at extremities like the forehead, or feet and hands were washed with cold water. As observed, cooling of extremities (like the forehead of humans) decreases the body temperature of a feverish human body. Given this analogy, broiler could decrease its body temperature by cooling off its extremities and the target was the feet of broilers through conduction heat transfer. Cold water from the cold sink (tank – ice chest) is pumped through the pipes with the help of small submersible pumps. Pipes with cold water running through it are to be placed strategically on the floor of pens for broilers to perch on to cool off. Broilers cool off body heat through the extremities (feet) and theoretically heat from the feet is transferred to the cold pipes. Aside from the heat gained from the environment, heat from the feet of broilers is gained by the chilled water through the pipes taken away from the vicinity of the broiler. This process continues until the broilers feel again its comfort zone. As consequence the broiler will gain a heavier body weight compared to other broilers experiencing heat stress.

The study aims to determine the effect of re-circulating cooling system in a modified poultry house for broiler production and determine the economic viability of the modifications. The improvement of the poultry housing for broiler production will help the farmers increase their income and will also help food security of the country. Researchers can also use the information derived from the study as a benchmark in further studies. If it is economically feasible then it can be applied to small scale broiler production for verification.

Materials and Methods

The study was conducted at the *Palayamanan* area at Bulacan Agricultural State College, Pinaod San Ildefonso, Bulacan approximately 15˚ 44’ N and 120˚ 31”E. A conventional poultry housing (naturally ventilated with slatted floor and slatted wall) housed the broilers. There were two (2) treatments and three (3) replications in completely randomized design (Figure 1). An area of 2 m^2 (1m x 2m) housed 16 broilers (PAES:402, 2001). For T_1, conventional slatted floor was used while for T_2, wherein cold water is circulated through the plastic pipe by a water pump. A simple refrigeration system was manually operated during 10:00 A.M. to 3:00 P.M. An ice chest loaded with ice served as tank. Water was pumped and delivered into the modified poultry house. The pvc pipes served as heat sink wherein broilers used them as perching branches when they want to cool off. Loadings of ice in the chest were done twice at 10AM and 12NN only.

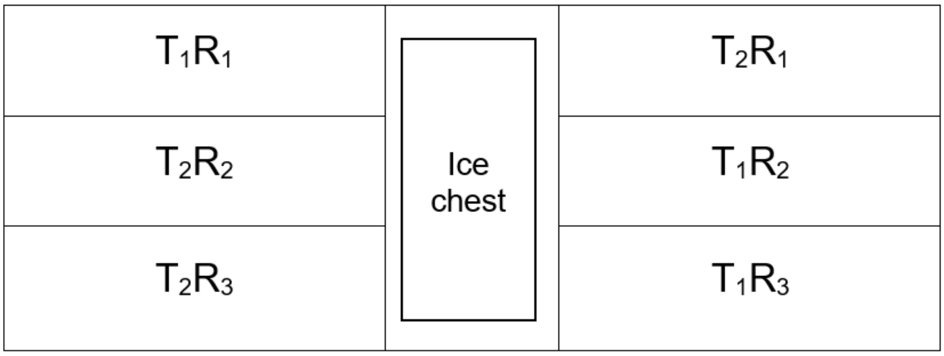

Figure 1. Designation of experimental units.

Observations were taken during the 3rd to 4th week of broiler production. Weight, mortality and feed conversion ratio (FCR) were determined. For the mortality rate, equation 1 was used. In determining the weight complete sampling was done in order to minimize stress on broilers and this is done every 3 days starting on 14th day up to 28th day. Growth rates per treatment were determined using equation 2. While for the FCR, equation 3 was used. Rates of increase of body weight were then graphed and relationship will be derived. A lower FCR value is desired in raising broiler hence it was determined per replication.

$$\%\text{,mortality rate}=\frac{\text{number of dead broilers}}{\text{total number of broilers}}*100 \qquad \text{equation 1}$$

$$\text{growth rate}=\frac{\text{total weight gained}}{\text{total number of days}} \qquad \text{equation 2}$$

$$\text{FCR}=\frac{\text{weight of feeds consumed}}{\text{total weight gain}} \qquad \text{equation 3}$$

Every cycle was 28 days and at the end of the study, broilers were sold. Revenues were used for roll-over capital for the next cycle to purchase feeds and stocks. There were two loadings/trials/cycles conducted for the study (April to May 2016 and 2017). Third trial was supposed to be conducted on April – May 2018, but due to early on-set of rainy season, environmental factors were not of optimum condition to set another trial since it will lead to outlier data.

Cost and return analysis was computed to know if the increase in body weight will compensate the increase of cost of modification of poultry housing. Method used to compare was by partial budget analysis.

Results and Discussion

Designing poultry housing should maximize the use of natural resources and minimize imported materials (Salman and Ayyash, 1981). The design (Figure 2) of recirculating cooling system was simple and was found to have water inlet temperatures ranging from 1.6°C to 31.73°C from 10 A.M. to 3 P.M. It also has corresponding water outflow temperatures of 5.97 – 32.07°C. Low water inlet temperatures were experienced when the block of ice was initially placed in the cooling system and these were observed during the 1st and 2nd loadings (10AM and 12NN respectively).

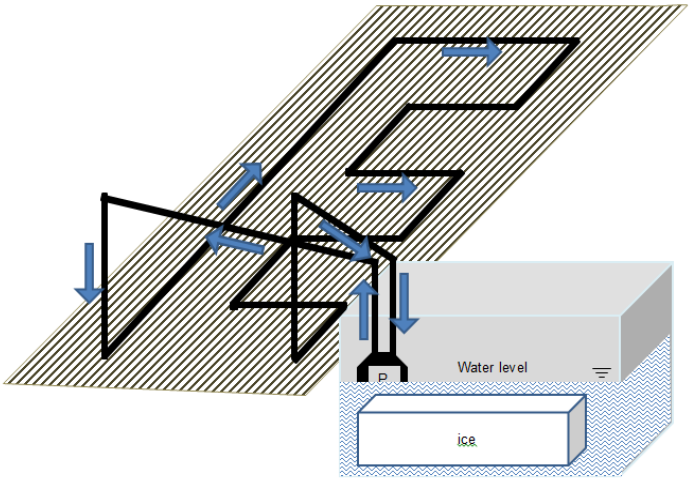

Figure 2. Flow of chilled water from the tank to the pipe network.

Pipes were used as cooling mode of broilers as it was observed that during high temperatures (normally 12 – 1 PM), broilers lay down (Figure 3) and perched on the pipes. By lying down, broilers increased their contact area to the pipes. If contact area is increased, rate of heat transfer through conduction also increases (Holman, 1997). Then dissipation of body heat increases.

(a) with cooling system (b) no modification

Figure 3. Behavior of broiler during conduct of study (a) perching and lying on the cooling system and (b) broilers flocking nearby the waterer

Average mortality rates of broiler in conventional poultry housing were 8.33% during 2016 and 4.17% during 2017, while broilers in modified poultry housing had 2.08% during 2016 and 0.00% during 2017 (Figure 4). On the average, mortality in conventional poultry house is 6.25% and 1.04% for mortality in modified poultry housing. It only means that the modification of poultry housing to combat heat stress lowers mortality rate during those 2 weeks of subjecting broilers to modification of poultry housing. According to PCAARRD (2018), recovery rate of 95-98% in poultry production is good indicator of good productivity. Hence, introduction of poultry housing modification leads to high recovery rate or low mortality rate which means that modification helps increase recovery rate of broiler production.

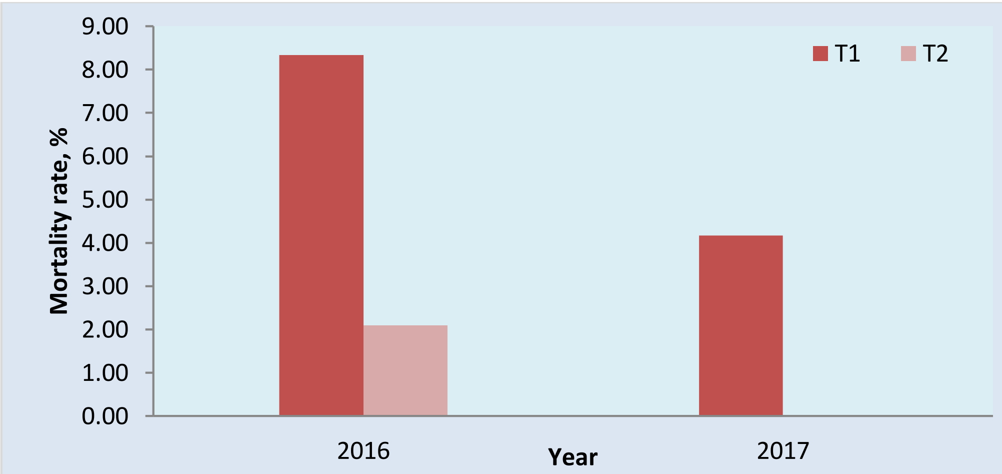

Figure 4. Mortality rate during growing stage of broiler production.

If taken into consideration the air temperature during growing stage, ranges from 31.50 - 35.75°C during 2016, and 32.28 - 34.72°C during 2017 (Figure 5). Death of broiler happened during days of high temperatures. Looking at the relative humidity during these days of death, it can be noted that it had high relative humidities, and it means that broilers could have experienced heat stress during that time. High temperature and relative humidity has fatal effect on broilers. The high temperature experienced by the broilers in conventional poultry housing exceeded the ideal comfort zone for rearing chicken which is 21-29°C (Clauer, 2009). Beg, et.al. (2011) also stated that there is higher bird mortality during summer due to the factor that the feather covering of the broiler prevents the heat to dissipate from the body. It was also stated that if heat becomes greater over long periods, birds might die. The study was conducted during the summers of 2016 and 2017, hence it can indicate that heat was the stressor of the broilers.

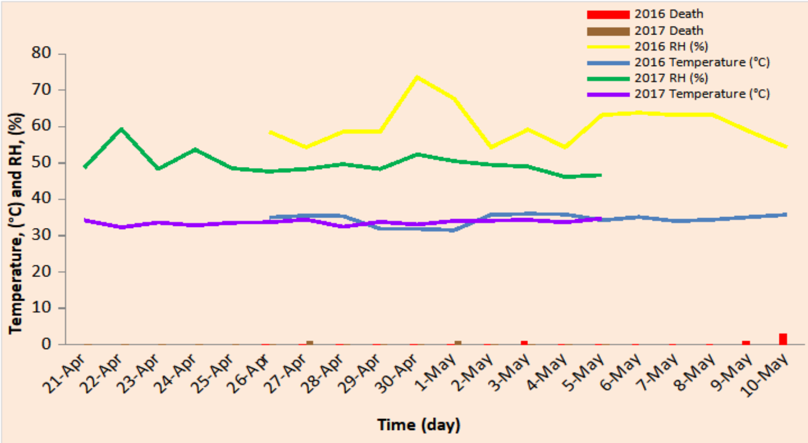

Figure 5. Mortality of broiler for conventional poultry housing.

The average weights of broilers after 4 weeks reared in conventional poultry housing were 1.24 kg and 1.20 kg for 2016 and 2017 respectively (Table 1). During 2016, temperature readings were high compared with 2017, it would mean that broilers could be stressed with high temperature. But 2017 broilers had lower average weight gained compared with 2016 broilers. It can be noted that although this is the case, the factor that might cause this could be because of less stocking density due to high mortality. If there are more space for every broiler available and less number of bodies that emitted heat, then broilers might be comfortable and exhibited high weight gained. This was also the findings of Lara & Rostagno (2013) that stated that stocking density has a major compounding factor to heat stress.

Table 1. Average weights of broiler during the study.

Reading	2016 T1	2017 T1	2016 T2	2017 T2
1 (14^{th} day)	0.42	0.32	0.40	0.33
2	0.54	0.53	0.55	0.56
3	0.69	0.75	0.70	0.78
4	0.85	0.88	0.87	0.92
5	1.04	1.01	1.06	1.05
6 (29^{th} day)	1.24	1.20	1.27	1.26

While for the modified poultry housing, the average weights were 1.27 kg and 1.26 kg for 2016 and for 2017 respectively. It can be seen in 2016, broilers in modified poultry housing (1.27 kg) has highly significant weight gained compared to broilers in conventional housing (1.24 kg). Also in 2017, 1.26 kg of broilers in modified is highly significant with 1.20 kg of broilers in conventional housing. These can also be seen on the average growth rate of broilers in every treatment (Table 2). It can be seen that 2017 broilers had high growth rate. This could be due to the fact that the temperatures during that time were stable compared with 2016. Broilers were comfortable with the environment resulting to higher growth rate and lower mortality rate. Broilers were observed lying down above the cooling system during times of high temperature. The modification of the poultry housing did some effects on broilers since it exhibited higher growth rate in broilers compared with broilers in conventional housing.

Table 2. Average weight gained of broilers.

Treatment	Weight gain (g)	
	2016	2017
T_1	39.36[a]	40.48[a]
T_2	41.76[b]	43.71[b]

Improving feed conversion ratio from the average 2.0 by lowering is of desirable factor in raising broiler as stated by PCAARRD (2018). The average FCRs for 4 weeks of raising broilers in conventional poultry housing were 2.46 and 2.50 for years 2016 and 2017 respectively (Table 3). On the other hand, broilers in modified poultry housing had 2.25 and 2.32 FCRs for years 2016 and 2017 respectively. This is not desirable since it's higher than the average FCR. But it can be noted that during the study, with broilers subjected to modification for 2 weeks, CFRs of broilers in modified housing were significantly lower than the CFRs of broilers in conventional housing. This means that modification of poultry housing will further bring down the CFRs. This might be the reason of lower overall CFRs of broiler produced in the modified housing compared with broilers in the conventional one. This is due to reduced feed intake of heat stressed broilers that resulted to lower body weight or growth rate as it maintained the homothermy (Feng, et.al. 2008; and Ojano-Dirain and Waldroup, 2002). Aside from the heat stress, factors such as type of feeds and its ingredients should also be considered as the affecting factor on FCRs.

Table 3. Feed conversion ratio before and after intervention.

Treatment	2016	2016 (with CS)	2017	2017 (with CS)
T_1	2.46	1.85	2.50	1.91
T_2	2.25	1.68	2.32	1.77

The cost of intervention by poultry housing modification might be compensated with higher weight gained by broilers. Assuming life of equipment and pipe fixtures or cooling system as 2 years (based on manufacturer's specifications for pump that will last 10,000 h of use). Additional operation cost is the electricity consumed during operation of re-circulating cooling system (10AM to 3PM). Computing broiler production for 2 years and using partial budget to compare the modified from the conventional housing (Table 4), the re-circulating cooling system had an added cost of Php 10,823.75. The additional income came from the difference on th average weights of broilers from the conventional and from the modified poultry housing. Due to the increase in body weight of broiler, the added cost of re-circulating cooling system was compensated with an added return, resulting to a net impact of PhP 8,616.25 on income. These computations are based on 144 broilers in a production cycle.

Table 4. Partial budget for poultry house modification.

Income Reducing		Income Increasing	
Added Cost	PhP	Added Return	PhP
Investment cost	9,574.00	Broiler revenue	19,440.00
Operation cost	1,249.75		
Total	10,823.75	Total	19,440.00
Net Impact		PhP 8,616.25	

Conclusion and Recommendation

Cooling system in a poultry house can help lower down the mortality rate, and increase the weight gain and feed conversion ratio as well. A simple cooling (refrigeration) system operated at times of high temperature will give an additional profit to broiler raisers. This was an experimental trial hence application of such system in small scale (20,000 heads) production is recommended in order to verify further the viability of such endeavor. Also, actual decrease of body temperature of broilers should be determined with the use of thermal scanner to lessen broiler stress to quantify heat loss through conduction.

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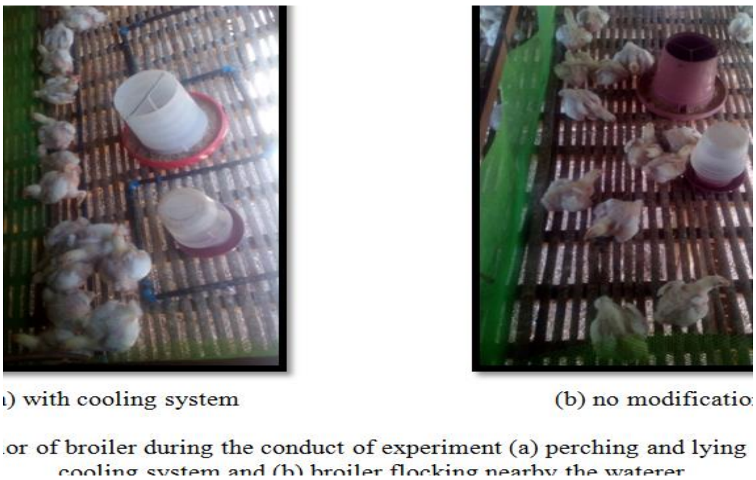
Appendices

APPENDIX A. PHOTO DOCUMENTATION

(a) (b)

During growing stages (3rd to 4th weeks).



APPENDIX B. Sample Analyses of Variance

Analysis of variance for average weight of broilers.

df	SS	MS	Fcal	Ftab	
				5%	1%
1	1350	1350	0.48	7.71	21.2
4	11333	2833			
5	12683				

Analysis of variance for average weight of broilers.

df	SS	MS	Fcal	Ftab	
				5%	1%
1	4816.667	4816.667	3.28	7.71	21.2
4	5867	1467			
5	10683				