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Comparison of Broiler Performance in Two Conventional and Environmentally Controlled Modern Broiler Houses in Tropics

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ABSTRACT

The purpose of this study was to evaluate broiler performance, environmental conditions and litter quality in two conventional and environmentally controlled condition modern broiler houses. Two consecutive experiments were conducted using 60800 one day old broiler chicks (Ross 308 strain) on a commercial poultry farm included two types of conventional and environmentally controlled modern broiler houses during summer and winter seasons of Shoush, Khuzestan province of Iran. In each experiment, a total of 30400 day-old broilers were placed into both houses. Average temperature and relative humidity of the ambient and inside of the conventional and environmentally controlled condition modern houses during summer and winter at two experiments were 39.4ºC, 30.5ºC, 29.3 ºC and 40.1%, 45.3%, 44.4%, and 12.9ºC, 28.5ºC, 28.6 ºC and 36.8%, 45.2%, 39.5 %, respectively. Bird performance including live body weight, feed intake, feed conversion ratio, mortality rate, production efficiency index and litter pH, moisture content and air ammonia levels were not significantly affected by types of the houses. However, the chickens grown in the environmentally controlled condition modern house, although raised at higher stocking density (20 *vs*. 16 Birds/m^2) than conventional house, had numerically lower mortality rate and greater production efficiency index probably due to improved environmental conditions trough proper ventilation applied in environmentally controlled condition modern house than conventional house. In conclusions, application of environmentally controlled condition modern house in addition of greater production efficiency index and less mortality rate can be useful in increasing stocking density of broiler chickens compared to conventional houses.

Keywords: Poultry house, environmental condition, ventilation, performance, broiler chicken.

INTRODUCTION

Improvement in animal breeding, nutrition and animal husbandry has led to change in modern poultry from the past birds. Accordingly, modern poultry particularly broiler chickens under intensive production are susceptible to many disorders, stressors and diseases more than ever before (Lin *et al*., 2006).Consequently, poultry in unfavorable environmental conditions cannot show their true genetic potential, therefore, leading to economic losses (Feddes *et al*., 2002). Providing a suitable place for growing the birds is one of important and basic issues in poultry production (Lacy and Czarick, 1992). The main reason to building houses for poultry is to provide protection from the weather. Many parameters such as temperature, humidity, etc. affect environmental conditions of within poultry house. Most of these parameters are dynamic and will frequently be changing depending on the weather conditions, season, location, time of day, etc. (Estevez, 2007). Effects of these parameters on poultry health, welfare and performance well are documented (Shane, 1994). One of the key parameters affecting poultry house environment is weather conditions. It has been indicated that any deviation from optimal environmental conditions controlling can have deleterious impacts on poultry welfare, health and performance. Some negative consequences of these variations from natural amplitudes are heat stress, cold stress, wet litter, ammonia emissions, etc. (Czarick and Lacy, 1990; Lacy and Czarick, 1992; Akyus, 2009).

Because of heat stress condition in tropics in comparison with moderate regions, typically lower densities are applying in broiler production. For example, in summer of Khuzestan province of Iran, stocking density of 10 to 14 Birds/m^2 is common in conventional houses in order to reduce heat stress effects on birds whereas, higher densities are typical at cooler seasons of the year which make problems such as wet litter and ammonia emissions which caused by poor ventilation and suddenly lost heat of within the house due to increasing ventilation rate for air exchange.

Poultry producers have experienced increased production efficiency that is somewhat attributable to improvement in housing technology and equipment (Liang *et al*., 2013). Nowadays, modern poultry houses with good construction insulation, ventilation design, within environmentally conditions control system and automatic equipments inside of the house provide the possibility of rearing the birds at higher stocking density (Puron *et al*., 1995; Estevez, 2007; Liang *et al*., 2013). Some researchers have introduced applying environmentally controlled condition poultry houses as an alternative way to achieve good performance and increasing stocking density in tropic areas (Czarick and Lacy, 1990; Puron *et al*., 1995; 1997). Therefore, the aim of this study was to comparing broiler performance, air and litter quality in two conventional and environmentally controlled condition modern broiler houses at different seasons in Khuzestan province of Iran.

MATERIALS AND METHODS

Housing and experimental procedure

This study was performed on a commercial broiler farm where both conventional and environmentally controlled conditions modern houses existed side by side. Building characteristics, ventilation system and equipments of both broiler houses are presented in Table 1. Two consecutive experiments were conducted using Ross 308 broiler chickens (n =60800) in two 42 days periods during summer and winter seasons of Shoush, Khuzestan province of Iran. In each experiment, a total of 30400 one day-old broiler chicks provided from a same local hatchery and were placed into both houses. Three jet heater were applied in both houses to supplying required heat for the birds. Setting the temperature in conventional house relied upon imbedded usual thermostats and an intelligent controlling system using a combination of house static pressure controlled sidewall inlets, foggers, minimum, transitional and tunnel ventilation fans were applied in environmentally controlled condition modern house.

Table 1. Building characteristics, ventilation design and equipments of broiler houses

Characteristics	Environmentally controlled	Conventional
House sidewalls (R-value, diameter)	Sandwich panel polyurethane (R7, 5cm)	Brick (R3.2, 32cm)
Roof type	Hangar (glass wool insulation + galvanized sheet)	Usual (brick housing)
Floor type	Concrete floor	Concrete floor
House width × length (m)	16×65	12×50
House Height (m)	2.8 (3.5 m in center)	3
Ventilation system	Combination of tunnel, transversal and minimum	Cross ventilation system (conventional)
Fans numbers and capacity (m^3/h)	5 (15000) & 6 (44000)	25 (7500)
Maximum ventilating capacity (m^3/h)	339000	187500
Evaporative cooling system	Cooling pad & misting fogging nozzles	Manual evaporative cooling system (traditional)
Numbers and surface area of evaporative cooling system (m^2)	2 (1×20)	25 (1×2)
Housing capacity (Birds)	20800	9600
Stocking density (Birds/m^2)	20	16

Bird Husbandry

Rearing management and composition of diets in both houses at each season were similar. All of the broiler chickens fed with a basal corn-soybean meal diet during 1-42 d of age. Corn and soybean meal-based diet were formulated to meet nutritional requirements of broilers according to NRC (1994) broiler recommendation. The composition of experimental diets and its nutritive characteristics are presented in Table 2.

Table 2. Composition and calculated analysis of diets in the both experiments

Item	Starter (1-7 d)	Grower 1 (8-14 d)	Finisher (15-28 d)	Withdrawal (28-42 d)
Ingredient, g/100g				
Yellow corn	53.5	57.0	59.5	63.3
Soybean meal (48% CP)	39.45	36.7	34.7	31.6
Soybean oil	2.5	2.0	1.5	1.0
Dicalciumphosphate	1.24	1.19	1.13	1.04
Oyster sell	1.50	1.55	1.60	1.50
Salt	0.24	0.21	0.20	0.15
DL-Methionine	0.15	0.08	0.10	0.14
L-Lysine	0.87	0.77	0.77	0.77
Vitamin premix[1]	0.25	0.25	0.25	0.25
Mineral premix[2]	0.25	0.25	0.25	0.25
Calculated nutrient				
ME, kcal/kg	3,000	3,000	3,000	3,000
CP, %	21.7	20.7	20.0	19.0
TSAA, %	0.90	0.80	0.70	0.65
Lys, %	1.10	1.00	0.90	0.85
Ca, %	0.93	0.93	0.93	0.87
available P, %	0.45	0.43	0.41	0.39

[1]The vitamin premix supplied the following per kilogram of diet: vitamin A, 8,000 IU; vitamin D3, 3,500 IU; vitamin E, 70 IU; vitamin K3, 5 mg; thiamine, 2 mg; riboflavin, 5 mg; vitamin B6, 1 mg; vitamin B12, 0.015 mg; niacin, 30 mg; choline chloride, 1000 mg; vitamin C, 300 mg; calcium D-pantothenate, 10 mg; folic acid, 1 mg.
[2]The mineral premix supplied the following per kilogram of diet: Fe, 250 mg; Zn, 150 mg; Cu, 100 mg; I, 1 mg, Se, 0.15 mg.

Feed and water were provided *ad libitum*. All diets were provided as mash form. In 2 first days of the two experiments, lighting schedule was continuous and afterward, a 23L: 1D lighting schedule was provided to end of the experiment.

Husbandry management in both houses at each season was identical. The conditions and standards of rearing used in this research were approved by the Ethics Committee for Animal Experiments of the Animal Science Research Institute of Iran.

Measurement of broiler performance parameters

At day 42 of age in each experiment, 5% of broilers in each house were weighed. Feed intake of each house was determined. Feed conversion ratio was calculated without adjusting for daily mortality.

Measured parameters on broiler houses and litter

Average, maximum and minimum dry bulb temperature and relative humidity of ambient and inside of the houses (front, middle and back) were weekly recorded during both summer and winter seasons (Table 3, 4).

Table 3. Temperature and relative humidity (RH) values of broiler houses during summer

Weeks	Conventional house				Modern houses				Ambient			
	Temp (ºC)			RH (%)	Temp (ºC)			RH (%)	Temp (ºC)			RH (%)
	Max	Min	Avg		Max	Min	Avg		Max	Min	Avg	
1	33.5	31.0	32.3	33.0	33.6	30.5	32.1	35.5	47.0	43.0	44.6	36.5
2	31.0	30.0	30.7	32.5	30.5	29.2	30.2	37.5	42.1	39.0	40.8	38.0
3	30.7	29.4	30.0	38.5	30.4	29.0	29.7	40.2	39.0	37.0	37.8	39.2
4	31.7	30.5	30.9	47.7	29.8	29.0	29.1	45.0	40.0	36.5	37.6	40.5
5	30.5	28.6	29.7	56.5	28.5	27.0	27.7	48.6	39.0	37.0	37.7	40.7
6	30.3	29.0	29.6	63.7	27.5	27.0	27.2	59.8	39.0	38.0	38.0	45.4

At day 42 of age, litter samples were collected from different positions of each house for determination of pH (1:10 litter per distillated water) and moisture content (at 105°C for 24 h). Each litter sample consisted of 12 subsamples of litter. The subsamples were collected from 4 positions of front, middle and back of each house.

Table 4. Temperature and relative humidity (RH) values of broiler houses during winter

Weeks	Conventional house				Modern houses				Ambient			
	Temp (ºC)			RH (%)	Temp (ºC)			RH (%)	Temp (ºC)			RH (%)
	Max	Min	Avg		Max	Min	Avg		Max	Min	Avg	
1	32.5	31.9	32.1	30.7	32.3	32.7	32.0	25.8	23.1	8.5	14	25.0
2	31.5	30.5	30.9	45.6	31.2	30.1	30.5	37.5	22.2	6.3	13.2	34.7
3	30.5	27.2	28.3	42.1	30.7	28.5	28.5	36.0	21.3	5.2	12.5	35.2
4	28.7	27.1	27.7	52.7	29.4	27.2	27.5	40.5	19.0	5.7	13.7	43.5
5	27.5	26.0	26.7	50.5	28.2	26.7	26.6	46.5	18.5	6.0	12.1	45.1
6	26.7	25.7	26.2	49.6	26.9	26.1	26.5	44.2	16.4	5.8	11.7	37.5

At day 42 of age, for measuring of ammonia levels in each house, first, all of the heating and ventilation systems turned off for one minute, then, an air sample (at height of 40 cm of litter) was drawn into an ammonia detector tube (Ammonia detector tube, 3La type, Gastec Co, Japan) by a manual pump (Gas sampling pump, GV-100S, Gastec Co, Japan). Corrected ammonia levels were determined after atmospheric pressure and temperature corrections.

Statistical Analysis

Data were analyzed according to the t-test procedure of SAS software, version 6.12 and effects were considered statistically significant when $P < 0.05$.

RESULTS AND DISCUSSION

Data of temperature and relative humidity were presented in table 3 and 4. Average temperature and relative humidity of the ambient and inside of the conventional and environmentally controlled modern broiler houses during summer and winter in both experiment were 39.4ºC, 30.5ºC, 29.3 ºC and 40.1%, 45.3%, 44.4%, and 12.9ºC, 28.5ºC, 28.6 ºC and 36.8%, 45.2%, 39.5 %, respectively.

There were no considerable differences in temperature (average, minimum and maximum) and relative humidity percentage values between both houses at summer and winter seasons. However, temperature and relative humidity controlling in environmentally controlled condition modern house partially was in better situation than conventional house at summer so that, maximum and average temperature (about 2 ºC) and relative humidity (2 to 4 %) in the last two weeks of study were lower than conventional house at summer.

During winter season, there were no substantially differences in temperature and relative humidity between both houses. Ventilation rate should be minimal in winter mounts of cool weather and the airflow over litter or manure in cool weather may be helpful in controlling moisture and ammonia levels.

As providing optimal environmental conditions of within poultry house are required for good rearing and high quality performance, hence, paying attention to good design and using appropriate equipments such as good structural insulation, ventilation (minimum, tunnel and transitional) systems, ventilation air inlets, evaporative pad cooling, foggers, etc. according to weather conditions of each area are important for providing optimum environmental conditions (Czarick and Lacy, 1990; Lacy and Czarick, 1992).

Broiler performance included live body weight, feed intake, feed conversion ratio, mortality rate and production efficiency index were not affected by broiler house type (Table 5).

Table 5. Comparison of broiler performance in two conventional and environmentally controlled conditions modern broiler houses during different seasons at day 42[1]

Parameter	Broiler house: Conventional	Broiler house: Environmentally controlled conditions modern	P-value
	Summer		
Live body weight (g)	1940.6±17.91	1944.9±14.34	0.853
Feed Intake (g/bird)	3526.2	3454.1	-
FCR (g/g)	2.06	2.03	-
Mortality rate (%)	27.52	25.96	-
production efficiency ratio	184.3	192.9	-
Litter moisture (%)	34.62±3.35	40.42±4.24	0.550
Litter pH	8.40±0.12	8.43±0.06	0.124
Air ammonia (ppm)	13.40±1.31	13.89±1.46	0.814
	Winter		
Live body weight (g)	1939.6±10.62	1967.2±14.96	0.142
Feed Intake (g/bird)	3542.2	3448.4	-
FCR (g/g)	2.07	2.00	-
Mortality rate (%)	17.80	11.45	-
production efficiency ratio	207.8	236.7	-
Litter moisture (%)	54.03±4.34	55.64±3.96	0.815
Litter pH	8.08±0.21	8.24±0.11	0.151
Air ammonia (ppm)	14.76±0.99	11.79±2.54	0.319

[1] None of these mean differences are statistically significant.

However, the broilers grown at environmentally controlled conditions broiler house, although raised at higher stocking density (20 *vs*. 16 Birds/m^2) than conventional broiler house, had numerically lower mortality rate and greater production efficiency index probably due to improved environmental conditions mainly due to better insolation of the house and proper ventilation applied in environmentally controlled conditions modern house compared to conventional house. Moreover, higher air velocity in modern broiler house in comparison to conventional broiler house may have made more coolness for birds which it is in agreement with previous studies (Lacy and Czarick, 1992; Furlan *et al*., 2000; Farhadi *et al*., 2012).

Tunnel ventilation is the best accessible management tool to prevent heat stress and mortality in broilers during hot periods of year (Lacy and Czarick, 1992). Lott *et al*., (1998) showed that broilers were raised in a tunnel ventilation system (higher air velocity on the birds) presented better weight gain and feed conversion ratio than the birds raised in a conventional system. In recent study, birds in environmentally controlled condition modern broiler house were grown at higher stocking density than conventional house (20 *vs*. 16 Birds/m^2, respectively).

Although the chickens grown in the both houses did not show significant differences in growth performance, however, based on literature reviewed, numerous studies clearly pointed out the effects of increasing stocking density on poultry particularly broiler chickens. As the consequences, high stocking density may lead to increasing deleterious impacts on environmental condition within the house and litter quality and negatively influence poultry welfare, health and performance (Shanawany, 1988; Bilgili and Hess, 1995; Dozier *et al*., 2005; Feddes *et al*., 2002; Knizatova *et al*., 2010).

In some studies, subsequent decline in air quality within poultry house have been reported by increasing stocking density (Zuidhof *et al*., 1995; Dawkins *et al*., 2004). Zuidhof *et al*., (1995) reported that subsequent decreased air quality due to stocking density increases; negatively affected turkey performance and increasing ventilation rate reduced the negative effects of increasing stocking density on birds. Finally, they suggested that ventilation rate had a greater effect on turkey performance than stocking density. Dawkins *et al*., (2004) concluded that environmental conditions includes air quality had more direct impact on broiler well-being than stocking density *per se*.

In the present study, house type had no any significant influence on measured parameters of litter and air of within broiler house included moisture percentage, pH and ammonia emissions. It seems that proper environmental condition in modern house and lower stocking density in conventional house caused no significant difference in litter quality between experimental broiler houses. Regards to the contributed factors in broiler production such as housing, environment, and management practices are closely intertwined in the production of broilers; therefore it is difficult to recognize the full contribution of each individual factor (Liang *et al*., 2013).

CONCLUSION

In conclusions, environmentally controlled modern broiler house with better environmental condition increased production efficiency index and lowered mortality rate. Moreover, possibility of raising the broilers at higher stocking density achieved without any reductions in performance. However, in this case needs to further studies related to economics of the construction and applied equipments in operating the modern houses and costs of energy usage should be considered.

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