



Introduction of a Greenhouse as an Alternative Housing System to a Conventional House and Its Impact on Broiler Performance and Blood and Carcass Variables

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Abstract

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A study was conducted to compare the growth performance as well as blood and carcass variables of two broiler strains reared in a conventional broiler house and a modified greenhouse equipped with cooling pads and tunnel ventilation system. Eight hundred day-old chickens of two commercial strains (Ross 308 and Lohmann) were selected and placed in 8 floor pens (4 pens of 50 broilers for each strain in each housing system). The pens were located randomly throughout the modified greenhouse or the conventional broiler house (two-way ANOVA design). The broilers were provided a standard starter and grower diets *ad libitum*. The environmental conditions (*i.e.* temperature, relative humidity, lighting program and ventilation rate) were kept similar between the two houses. The results showed that the birds in the greenhouse consumed significantly ($P < 0.05$) more feed during the starter period (1-21d) and throughout the trial (1-42d) in comparison with those reared in the conventional house. Strain difference and strain \times house interaction had no significant effect on the measured parameters *i.e.* body weight gain, feed conversion ratio, hematocrit, heterophil:lymphocyte ratio, serum nitric oxide concentration, carcass and breast yields. However, birds reared in the greenhouse deposited more fat in their abdominal cavity compared to their counterparts in the conventional house ($P < 0.05$). Interestingly, from the economic point of view, the construction cost of a greenhouse was estimated approximately one-third of a conventional house (≈ 40.00 vs 120.00 US\$ per square meter). In conclusion, modified greenhouses equipped with cooling pads and tunnel ventilation system are recommended for low-cost rearing of broiler chickens.

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Introduction

Construction cost is considered as an important economic obstacle in commercial broiler practices. Cost is the biggest consideration when deciding whether to switch from the use of conventional to an alternative house for poultry. During the last decade, there has been a clear tendency toward alternative cost-effective poultry houses. Recently, greenhouse barns have received a great deal of attention as housing for calves and cows. In addition to lower construction costs, these modified greenhouses also pose another potential advantage over the conventional ones which is the faster construction process (Bartok, 1996).

Therefore, the objective of the present study was to evaluate the growth performance as well as the physiological variables of broilers reared in a low-cost modified greenhouse constructed to meet the birds' environmental requirements and welfare. A conventional broiler house was considered as control. To the best of our knowledge, the present research is the first report on the use of a greenhouse for broilers production while comparing to a conventional house.

Materials and Methods

Design and construction of the greenhouse

The dimensions of the greenhouse were 12.5×8 m, with an average height of 4 m similar to those of the conventional house. The greenhouse was built with two thick and dim nylon layers to ensure maximum light proofing. Moreover, a 30 cm gap between the two layers provided an adequate insulation with an R-value of 20 kelvin square meters per watt (Weaver, 2002). Such R-value was recommended for the region. The floor was built with cement covered with wood shavings for litter materials. The capacity of the tunnel ventilation system was 300 m³ per minute. A cooling pad area of 6 m² was calculated and placed at one end of the greenhouse opposite to the fans to provide an evaporative cooling system. An auxiliary air conditioner was also placed in the house to serve as a reserve cooling system in case the cooling pad-tunnel ventilation system was inadequate at extremely high temperatures. A composition of chalk and water was prepared and spread over the outer layer of nylon to reflect solar radiations. Such composition had a very low absorptivity for short wavelength radiations and a high emissivity for long wavelength radiations (Charles and Walker, 2002) and resulted in improved light proofing. Sectional views of the greenhouse are depicted in Figures 1, 2 and 3.

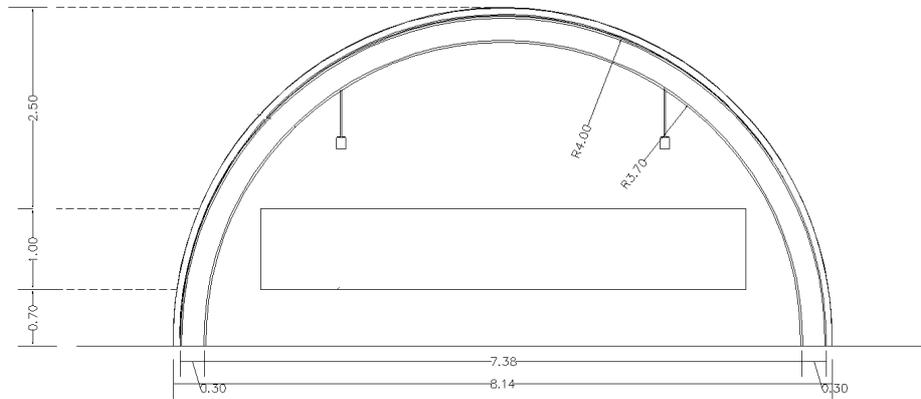


Figure 1. Sectional view of the east endwall.

Rectangular is the cooling pad area
 The gap between two layers is 0.3 m
 All values are presented in meters (m)

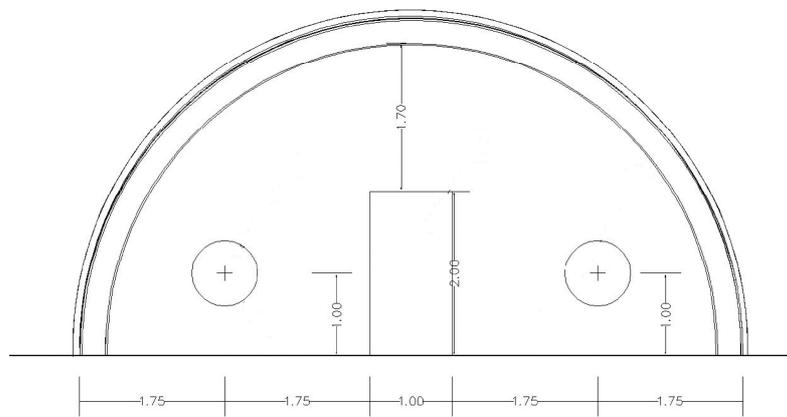


Figure 2. Sectional view of the west endwall.

Circles are fan areas
 Rectangular is the entrance
 Indoor height = $2+1.70 = 3.70$ m; Outdoor height is $3.7+0.3= 4$ m
 All values are presented in meters (m)

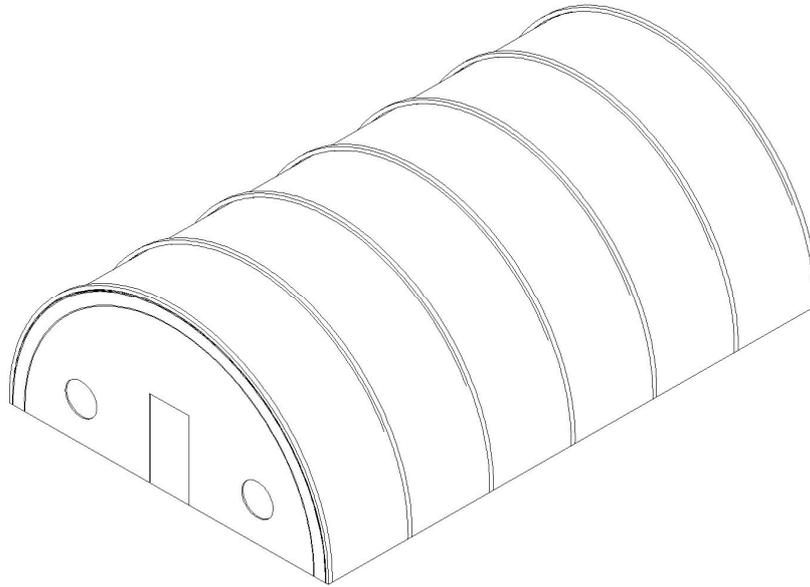


Figure 3. Top view of the greenhouse.

Husbandry and birds

The experiment was conducted in a moderate spring in Shahrekord, a city located in Midwest of Iran, a tropical area with an altitude of 2100 m above the sea level. The ambient temperature ranged between a minimum of 7 °C to a maximum of 26 °C. The relative humidity was 25% on average. Four hundred day-old chickens of Ross 308 strain (strain A) and 400 day-old chickens of Lohmann strain (strain B) were obtained from a commercial hatchery (Sabet hatchery, Guilan, Iran). The chickens of both strains were obtained from 32 wk old breeders to eliminate the effect of breeder's age. All chickens were transported by an incubator truck to Shahrekord and weighed upon arrival. In both enclosures, the chickens from each strain were randomly assigned to four floor pens (2×2.5 m² and 50 birds per pen) with wood shaving litter. Hence, there were 8 floor pens in each enclosure, 4 allocated to strain A and 4 allocated to strain B. At the beginning of the trial, the average weight of the chickens in all pens was similar (44±0.37 g on d 1). Feed and water were provided *ad libitum* throughout the trial. The temperature of both experimental facilities was maintained at about 32 °C for Week 1, 29 °C for Week 2, 26 °C for Week 3, and 22 °C until the end of the experiment. In both enclosures, the lighting system was designed to provide 15 lux with a schedule of 23L:1D. The experiment was commenced on d 2 and lasted up to d 42.

Experimental diets

All birds were fed a single diet formulated to meet the broiler requirements according to the recommendations of NRC (1994) for each feeding phase. Diets were offered in a pellet form. Feeding phases included the starter [0-3 wk of age; 21.4% CP, 3000 ME (Kcal/Kg)] and the grower [3-6 wk of age; 18.7% CP, 3000 ME (Kcal/Kg)] (Table 1).

Table 1. Composition of the experimental diets fed to broilers (as fed)

Feedstuffs	Starter Period (%)	Grower Period (%)
Corn	56.85	64.45
Soybean meal(44%CP)	34.30	30.10
Fish meal (60%CP)	2.50	-
Soya refined oil	2.70	2.00
Dicalcium phosphate	1.30	1.20
Oyster shell	1.30	1.40
salt	0.40	0.30
Trace mineral premix ¹	0.25	0.25
Vitamin premix ²	0.25	0.25
DL-methionine	0.15	0.05
<i>Analyzed values</i>		
ME (Kcal/kg)	3000	3000
CP (%)	21.40	18.70
Met (%)	0.47	0.36
Met+Cys (%)	0.85	0.66
Lys (%)	1.13	0.95
Arg (%)	1.30	1.15
Thr (%)	0.79	0.69
Ca (%)	0.93	0.84
Available P (%)	0.42	0.32
Na (%)	0.19	0.14

¹Provided at the following rates per kilogram of diet: Mn (from MnSO₄·H₂O), 40 mg; Zn (from ZnO), 40 mg; Fe (from FeSO₄·7H₂O), 20 mg; Cu (from CuSO₄·5H₂O), 4 mg; I (from Ca (IO₃)₂·H₂O), 0.64 mg; Se, 0.08 mg (from sodium selenite).

²Provided at the following rates per kilogram of diet: 3600IU vitamin A, 800 IU vitamin D₃, 7.2 IU vitamin E, 0.72 mg vitamin B₁, 3.3 mg vitamin B₂, 0.4 mg vitamin B₃, 1.2 mg vitamin B₆, 0.6 mg vitamin B₁₂, 1.6mg vitamin K₃, 0.5mg folic acid, 2mg H₂, 200mg Choline chloride.

Measured parameters

Body weight and feed intake (FI) were recorded at the beginning and the end of the feeding phases and feed conversion ratio (FCR) was calculated, accordingly. Blood samples (3 mL) were collected through the wing vein from four birds per

pen (16 birds / treatment) at 42 d of age. Haematocrit was measured using heparinised microcapillary tubes centrifuged ($5000g \times 5$ min) in a microlitre centrifuge (BMC 24 Microhaematocrit centrifuge, Pars Azma Co., Isfahan, Iran). Blood smears were also prepared for counting heterophils and lymphocytes (Gross and Siegel, 1983). Blood samples were then centrifuged at 2500g for 10 min to obtain serum samples. Sera were analyzed for nitric oxide (NO) according to Hortelano *et al.* (1995). In brief, 250 μ L of the serum was added to 1 mL of Griess reagent consisting of a mixture (1:1) of 1% sulfanilamide in 5% phosphoric acid and 0.1% 1-naphthylethylenediamine. This reagent provides a red-violet color in the presence of nitrite, the stable form of nitric oxide. Assay was performed based on a standard curve using the nitrite solution (NaNO_2) at the concentrations ranged from zero to 140 μ Mol/L and the optical densities were measured at 540 nm by means of a spectrophotometer (Corning 480, USA). All chemical reagents were purchased from Sigma-Aldrich Co. (Sigma-Aldrich Co. St Louis, MO, USA).

After the blood samples were collected, the birds were killed. Performance parameters measured were live body weight, hot carcass weight, abdominal fat pad weight, and breast weight (skinless and boneless, *Pectoralis major* and *Pectoralis minor*).

Statistical Analyses

The data were analyzed in a completely randomized design with a 2 \times 2 factorial arrangement of the treatments using the JMP software (SAS, 2005). Differences were considered significant when $P < 0.05$. Means were separated by Duncan's multiple range test.

Results

The results obtained on feed intake, body weight gain and feed conversion ratio of the broiler strains reared in the conventional house and the greenhouse during different stages of the trial are presented in Table 2. The type of housing had a significant effect on feed intake in the starter period (2-21d) and throughout the experiment (2-42d). It can be observed that birds raised in the greenhouse consumed more feed than those reared in the conventional one. However, this difference in feed intake was not statistically significant during the growing stage (21-42d), although it was numerically in favor of the greenhouse treatment.

There were no differences caused by house type, bird strain, nor by their interaction with weight gain, FCR, haematocrit, heterophil:lymphocyte (H:L) ratio, serum NO concentration, carcass and breast yields (Table 2). However, birds reared in the greenhouse deposited more fat in their abdominal cavity compared to their counterparts in the conventional one ($P < 0.05$).

Table 2. Performance, blood, and carcass parameters of two broiler strains reared at a conventional broiler house and a greenhouse

House Strain	Conventional		Greenhouse		Pooled SEM	House	Strain	Interaction
	Ross	Lohmann	Ross	Lohmann				
FI (g/bird)								
2-21d	641	632	659	649	7.1	*	NS	NS
21-42d	2674	2670	2731	2700	18.2	NS	NS	NS
2-42d	3315	3331	3390	3350	17.1	*	NS	NS
BWG (g/bird)								
2-21d	402	398	415	409	6.62	NS	NS	NS
21-42d	1461	1406	1456	1469	26.1	NS	NS	NS
1-42d	1854	1804	1871	1879	24.7	NS	NS	NS
FCR								
2-21d	1.59	1.59	1.58	1.59	0.02	NS	NS	NS
21-42d	1.83	1.85	1.88	1.90	0.03	NS	NS	NS
2-42d	1.78	1.81	1.81	1.79	0.02	NS	NS	NS
Hematocrit (%)	39.0	38.4	39.2	39.1	0.50	NS	NS	NS
H: L	0.15	0.19	0.14	0.20	0.03	NS	NS	NS
NO (μ Mol)	6.1	5.9	5.7	5.5	0.33	NS	NS	NS
Carcass yield (%)	72	71	70	71	0.89	NS	NS	NS
Breast yield (%)	29.3	29.7	29.5	29.1	0.75	NS	NS	NS
AFP (%)	2.65	2.73	3.11	3.23	0.13	*	NS	NS

*Significant difference at $P < 0.05$. NS, non-significant.

Blood and carcass values are expressed as mean of 16 repetitions.

H:L = heterophil:lymphocyte ratio, NO = serum nitric oxide, AFP = abdominal fat pad

Discussion

The higher feed intake of birds reared in the greenhouse compared to those kept in the conventional house was likely attributed to the higher intensity of light in the greenhouse. Despite all the attempts made in making the greenhouse as light-proof as possible, some unwanted light could still penetrate inside the greenhouse during day time hours. This observation was previously described by Lien *et al.* (2007), that a transient elevation in feed consumption was observed at a higher light intensity (10 lux) compared to a lower one (1 lux). In studies in which light intensity was gradually reduced (Downs *et al.*, 2006; Newberry *et al.*, 1986), feed consumption was not decreased following the decrease in intensity. Abrupt changes in lighting programs, such as from long to intermittent, have also been observed to result in short term decreases in feed consumption (Buyse *et al.*, 1996). Feed intake of both strains was very similar and the strain effect was insignificant. The interaction was not significant either. This implies that both strains responded to each environment similarly.

Despite differences in feed intake, there were no differences caused by strain, house, or their interaction with body weight gain or FCR. Although the main differences between the two housing systems were not significant in either of the experimental periods, the birds in greenhouse gained 2.6% more than their counterparts in the conventional house throughout the second part of the experiment (21-42d). The higher weight gain is in part, caused by higher feed consumption. Furthermore, as mentioned before, the light intensity was inevitably higher in the greenhouse and this might be contributed to enhanced weight gain. Lien *et al.* (2008) indicated that body weight of broilers reared under higher intensities of light was 3.9% greater than those grown under lower intensities of light, which is consistent with the findings reported herein. The weight gain response of both strains was very close and differences were insignificant. The interaction of house type and strain was not significant either. This implies that the response of the strains did not differ in the two environments. As relatively similar changes were observed in both weight gain and FI between the treatments throughout the trial, FCR was not significantly affected. In some reports on light intensity, FCR was not affected by light intensities of 18 *vs* 0.6 foot candle (Newberry *et al.*, 1986).

Although hematocrit was not statistically different between the broilers reared in both houses as well as among the strains, but the hematocrit values reported herein were greater than the values normally reported for broilers (Khajali *et al.*, 2011). The greater hematocrit values are associated with the high altitude of the experiment's location. Rearing the birds in a high altitude region as conducted in the present study (2100 m) led to a severe hypobaric condition. The partial pressure of oxygen drops approximately 7 mmHg for each 1,000 m increase in altitude, reducing the amount of oxygen available to the hemoglobin in red blood cells as blood passes through the lungs. This is equivalent to a drop of approximately 2.5% in the air oxygen for every 1,000 m increase in altitude (Julian, 2007). The concentration of oxygen in our study was 16%. Beker *et al.* (2003) reported that hematocrit of broiler chickens reared at 16% oxygen concentration was significantly lower than that of the birds reared at 20.6% oxygen concentration (35.7 *vs* 31.8%).

Nitric oxide, synthesized from arginine, is a simple molecule with many physiological and immunological roles in bird's body. It is responsible for vasodilatation that is essential for the regulation of blood pressure (Khajali and Wideman, 2010). The physiological function of nitric oxide in the airways is dilatation of bronchial smooth muscle (Ricciardolo *et al.*, 2003). Diminished nitric oxide availability and production has been implicated in the pathogenesis of pulmonary hypertension and ascites in broiler chickens (Izadinia *et al.*, 2010). No

significant difference in NO caused by house type, strain or the house and strain interaction were observed.

The H:L ratio is an index showing stress in the chicken (Gross and Siegel, 1983). Lack of significant difference between the houses in terms of H:L ratio shows that broiler chickens could be successfully raised in the greenhouse under stress-free conditions.

The effects of the main treatments as well as the interaction of house type and strain were not significantly different on carcass and breast yields which further suggest the appropriateness of the greenhouse for broiler production. The abdominal fat deposition was significantly ($P<0.05$) higher in the birds reared in the greenhouse than those grown in the conventional house. The higher fat deposition is due to higher feed consumption. It has been shown that restriction on feed intake results in reduced fat deposition in broiler chickens (Khantaprab *et al.*, 1997; Crespo and Esteve-Garcia, 2001). As indicated in Table 2, broilers reared in the greenhouse consumed significantly ($P<0.05$) higher feed compared to their counterparts in the conventional house.

Conclusions

Growth performance and blood variables were not significantly different between the birds in the greenhouse and those in the conventional house. Nevertheless, birds raised in the greenhouse consumed more feed and consequently deposited more body fat when compared to those reared in the conventional house. From the economic point of view, the construction cost of a greenhouse was estimated approximately one-third of a conventional house (≈ 40.00 vs 120.00 US\$ per square meter). Therefore, modified greenhouses equipped with cooling pads and tunnel ventilation system is recommended for low-cost rearing of broiler chickens. The findings of this experiment indicate that a greenhouse can be successfully used for rearing broiler chickens at high altitude and tropical conditions with a reasonably low cost. The present study was conducted in spring and more research needs to be done in the other seasons to make a more generalized conclusion on such housing impact on broiler production efficiency.

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