Effect of Differing Temperature Cycles on Egg Shell Quality and Layer Performance

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(Received for publication July 14, 1980)

ABSTRACT Egg shell quality deteriorates when the laying hen is exposed to high environmental temperatures. Within the continental United States, the normal spread during the summer months between the high and low temperature within a 24-hr period is 11 to 14 C degrees. Laying hens exposed to a 24-hr linear temperature cycle ranging from 26.7 to 35 C had a significantly poorer egg shell breaking strength, a thinner egg shell, and a significantly greater body-weight change than hens exposed to temperature cycles of 21.1 to 35 C and 15.6 to 35 C. No significant difference in performance existed in hens exposed to 24-hr linear temperature cycles of 21.1 to 35 C and 15.6 to 35 C.

Use of ventilation fans at night reduces laying house temperatures to near the minimum daily temperature, which normally occurs just before sunrise.

(Key words: chickens, egg production, environmental temperature, egg shell quality)

1981 Poultry Science 60:733–737

INTRODUCTION

Egg shell quality deteriorates when the laying hen is exposed to high environmental temperatures (Warren and Schnepel, 1940; Wilhelm, 1940; Heywang, 1946; Wilson, 1949; Hutchinson, 1953; Mueller, 1959, 1961; Harrison and Biellier, 1969; de Andrade *et al.*, 1976, 1977). Wilson *et al.* (1972) noted that shell thickness and breaking strength were superior for layers exposed to cyclic temperatures compared to those exposed to constant temperatures. Miller and Sunde (1975) noted that layers exposed to a constant high temperature (32 C) had a poorer egg shell quality than those exposed to a 24-hr temperature that cycled 6 C degrees above and below 32 C.

During the summer months in the continental United States, the normal spread between the high and low temperatures within a 24-hr period is 11 to 14 C degrees. The amount of sensible heat generated by White Leghorns in an ambient temperature of 30 C is 3 kcal/hr/kg of body weight (Ota and McNally, 1961). This heat is removed from the poultry house by an increase in the temperature of ventilation air as it flows through the house; at a ventilation rate of 7.3 g of air/hr/kg of body weight, the increase in air temperature to remove the sensible heat would be 1.1 C. Therefore, at an outside temperature of 30 C, the lowest temperature that could be expected in the laying house would be about 31 C, unless there is some form of evaporative cooling. This principle also applies to the low-temperature portion of the diurnal temperature cycle. However, as the ambient temperature decreases, the sensible heat produced by the hens increases; at 20 C ambient, White Leghorns produce 3.75 kcal/hr/kg of body weight (Ota and McNally, 1961) so that the lowest temperature in the poultry house with a ventilation rate of 7.3 kg of air/hr/kg of body weight at night would be about 22 C. Evaporative cooling effects would not be operative at the high humidity levels typical of nighttime.

The objective of this study was to determine whether lowering the temperature during the cool portion of the 24 hr in summer affected layer performance, particularly shell quality.

EXPERIMENTAL PROCEDURE

One 4-week (preliminary) and two 8-week trials were conducted. The treatments were 24-hr linear temperature cycles of 26.7 to 35 C, 21.1 to 35 C, and 15.6 to 35 C. The dew point was a constant 15.6 C. A battery containing 16 compartments 36 by 67 cm (37 cm high) was placed in each of three controlled environment chambers. The chambers were based on a design described by Reece and Deaton (1969). Three layers were placed in each battery compartment for a total of 48 layers for each trial and each temperature treatment.

The 35 C temperature was attained each day at 1600 hr and the low temperature was attained each day at 0400 hr. Light from incandescent bulbs was supplied from 0500 to 2100 hr. Feed and water were supplied *ad libitum*. Eggs were counted and collected daily from each chamber. Initial and final body weights and feed consumption data were recorded. All eggs laid during the 5th day of each week were weighed, and their breaking strength and shell thickness were recorded. Egg shell breaking strength was determined with a universal testing instrument by the technique described by Reece and Lott (1975). Shell thickness was measured with a micrometer. We used analysis of variance with Duncan's (1955) multiple range test to separate significant treatment means. The basal layer diet contained 17% protein and a metabolizable energy value of 2,889 kcal/kg. The calcium and available phosphorus levels were 3.25 and .60%, respectively.

RESULTS AND DISCUSSION

The results of the 4-week preliminary trial are given in Table 1. The hens were 15 months old when the experiment started. The results included a variable hen-day production and feed efficiency (grams of feed/gram of egg), with little difference in average egg weight. However, feed consumption decreased as temperature increased; the birds in the lowest temperature cycle gained weight. The hens in the highest temperature cycles had the lowest egg shell breaking strength and the thinnest egg shells (Table 1). The randomness with which the hens were allotted to a treatment created an unequal initial body weight in this trial. The hens exposed to the temperature cycle of 15.6 to 35 C had an average initial weight of 1,504 g, while the hens exposed to the temperature cycles of 21.1 to 35 C and 26.7 to 35 C had average initial weights of 1,569 and 1,573 g, respectively.

The hens used in trials 2 and 3 (Tables 2, 3, and 4) had initial weights of 1,440, 1,453, and 1,457 g for trial 2 temperature cycles of 15.6 to 35, 21.1 to 35, and 26.7 to 35 C, respectively, and 1,553, 1,547, and 1,547 g for the same trial 3 temperature cycles, respectively. The hens used in trial 2 were 7 months old when the trial started, and those used in trial 3 were 9 months old when the trial started. The results show that the laying hens exposed to the temperature cycle of 26.7 to 35 C had a significantly lowered egg shell breaking strength (Table 2) with a significantly thinner shell (Table 3) than the hens exposed to the temperature cycles of 21.1 to 35 C or 15.6 to 35 C. Lowering the temperature from 21.1 to 15.6 C during the 24-hr period did not significantly improve egg shell breaking strength (Table 2) or egg shell thickness (Table 3).

Hen-day production, feed consumption, egg weight, and feed efficiency (grams of feed/gram of egg) did not differ significantly between the three temperature-treatment groups (Table 4). Numerically, feed consumption and egg weight were lower for the group exposed to the temperature cycle of 26.7 to 35 C than for the group exposed to the temperature cycles of 21.1 to 35 C or 15.6 to 35 C in all three trials (Tables 1 and 4). The hens exposed to the temperature cycle of 26.7 to 35 C had a significantly greater body-weight change than those exposed to the temperature cycles of 21.1 to 35 C or 15.6 to 35 C (Table 4). In all three trials the hens exposed to the temperature cycle of 26.7 to 35 C lost weight (Tables 1 and 4).

TABLE 1. *Effect of differing temperature cycles on laying performance (preliminary trial, 4-week study)*

	Temperature, C[a]		
	15.6 to 35	21.1 to 35	26.7 to 35
Hen-day production, %	54	58	47
Feed consumption, (day-g)	104	100	97
Egg weight (g)	58	58	57
Body weight change (g)	+31	-61	-42
Feed efficiency (g feed/g egg)	3.3	3.0	3.6
Egg shell breaking strength (kg)	3.15	3.12	2.90
Egg shell thickness (mm)	.323	.325	.314

[a] A 24-hr temperature cycle from 35 C to either 15.6, 21.1, or 26.7 C, then back to 35 C, was used.

TABLE 2. *Effect of differing temperature cycles on egg shell breaking strength*

Days after temperature exposure	Egg shell breaking strength (kg)								
	Trial 2			Trial 3			Average Trials 2 and 3		
	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C
3	. . .	. . .	. . .	3.15	3.19	3.00	3.15	3.19	3.00
10	3.40	3.42	3.11	3.30	3.22	3.05	3.35	3.32	3.08
17	3.28	3.32	3.08	3.20	3.33	2.90	3.24	3.33	2.99
24	3.30	3.32	2.91	3.16	3.08	2.94	3.23	3.20	2.93
31	3.40	3.49	3.09	3.24	3.16	2.90	3.32	3.33	3.00
38	3.14	3.42	3.03	3.24	3.10	2.86	3.19	3.26	2.95
45	3.46	3.39	3.14	3.10	3.17	2.92	3.28	3.28	3.03
52	3.56	3.43	3.08	3.21	3.20	2.97	3.39	3.32	3.03
$\bar{X}$	3.36	3.40	3.06	3.20	3.18	2.94	3.27[a]	3.28[a]	3.00[b]

[a,b] Differing letters between treatment means (average trials 2 and 3) denote significant difference at the $P \leqslant .05$ level according to Duncan's multiple range test.

TABLE 3. *Effect of differing temperature cycles on egg shell thickness*

Days after temperature exposure	Egg shell thickness (mm)								
	Trial 2			Trial 3			Average Trials 2 and 3		
	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C
3	. . .	. . .	. . .	.309	.309	.303	.309	.309	.303
10	.317	.312	.302	.322	.315	.309	.320	.314	.306
17	.318	.315	.304	.324	.320	.310	.321	.318	.307
24	.316	.321	.304	.331	.322	.312	.324	.322	.308
31	.317	.316	.306	.330	.320	.306	.324	.318	.306
38	.313	.325	.310	.324	.310	.303	.319	.318	.307
45	.321	.315	.307	.317	.312	.293	.319	.314	.300
52	.323	.323	.300	.315	.312	.307	.319	.318	.304
$\bar{X}$	.318	.318	.305	.322	.315	.305	.319[a]	.316[a]	.305[b]

[a,b] Differing letters between treatment means (average trials 2 and 3) denote significant difference at the $P \leqslant .05$ level according to Duncan's multiple range test.

TABLE 4. *Effect of differing temperature cycles on hen-day production, feed consumption, egg weight, body weight change, and feed efficiency*

	Trial 2			Trial 3			Average Trials 2 and 3		
	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C	15.6 to 35 C	21.1 to 35 C	26.7 to 35 C
Hen-day production, %	65	65	69	79	73	77	72^{a}	69^{a}	73^{a}
Feed consumption (day-g)	105	104	93	103	100	98	104^{a}	102^{a}	96^{a}
Egg weight (g)	58	57	56	56	55	54	57^{a}	56^{a}	55^{a}
Body weight change (g)	+22	+13	-14	-27	-49	-72	-3^{a}	-18^{a}	-43^{b}
Feed efficiency (g feed/g egg)	2.8	2.8	2.4	2.3	2.5	2.4	2.6^{a}	2.7^{a}	2.4^{a}

[a,b]For trial means within each row, differing letters denote significant difference at the $P \leqslant .05$ level according to Duncan's multiple range test.

If diet formulations can be used to improve shell quality under high temperature stress, formulating diets to attain a neutral or positive body-weight change might have potential. de Andrade *et al.* (1977) concluded, however, that diet had no effect on the various measures of shell quality (specific gravity, shell thickness, and percent true shell) when Single Comb White Leghorn pullets were exposed to elevated temperatures. These authors were able to obtain a slight weight gain under a high temperature regimen by feeding a high nutrient-density diet.

In trial 3 the hens exposed to all three temperature regimens lost weight (Table 4). Trial 3 started in January. The hens came from a house with no heat available, so they had acclimated to a low temperature. They were given a 3-day acclimation period at 27 C before they were exposed to the high cyclic temperatures. The hens for trial 2 were started in November, and those for trial 1 in September.

Mortality was not significantly affected by temperature treatment applied. Only 4 hens died of the 432 used during the three trials.

Within the continental United States extremely high temperatures generally occur during an 8-week period (July and August). Lowering the laying house temperature during the cool portion of the 24-hr period from 26.7 to 21.1 C significantly improved egg shell quality as measured by breaking strength and egg shell thickness.

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