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The effects of high setter and hatcher temperatures during incubation on slaughter weight and carcass yield in broilers

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Abstract: This study was carried out with the aim of determining the effects of higher setter and hatcher temperatures on slaughter weight and carcass yield. In experiment 1, setter temperatures were applied as control (37.8–38.2 °C) and high (38.9–40.0 °C) between days 10 and 18 during incubation. In experiment 2, hatcher temperatures were applied as control (36.8–37.0 °C) and high (38.8–39.0 °C) during the hatching period. A total of 240 chicks from each experiment were randomly selected after the hatching process was complete. At the end of the growing period, a total of 120 broilers from each experiment were weighed and slaughtered at 42 days of age. The carcass weight was lower in the higher temperature groups in both experiments. In the higher setter temperature group, the breast weight was lower with a value of 981.4 g, but the percentage of breast was higher with a value of 45.59%. In experiment 2, the weight and the percentage of breast was similar in the control and high hatcher temperature groups. In conclusion, slaughter weight and carcass yield are affected by higher setter and hatcher temperatures.

Key words: Incubation temperature, slaughter, carcass yield

1. Introduction

The relationship between incubation and growing period has recently gained more importance with the use of high-yielding strains in broiler production. While broilers reached live weights of approximately 2000 g in 50 days in the 1980s, this time period was reduced to 39 days for the same live weight in the 2000s. Therefore, whereas the lifespan of a broiler with incubation period was approximately 71 days in the past, it had been reduced to approximately 60 days in 2004. As a consequence, the rate of time in incubator to total lifespan has increased from 30% to 35% (1,2). When considering these rates, the incubation period has gained increasing importance. It is well documented that incubation conditions affect embryo development and subsequently broiler performance (3–5).

Incubation temperature is one the most critical factors during incubation (6,7). In large-scale hatcheries, especially during the second stage of the incubation period and especially after the ninth day of incubation, optimum temperature ranges could not be achieved because of excessive heat production by developing embryos (7–9) and some incubator cooling and ventilation problems (10,11).

Fluctuations in egg temperature and accordingly incubation temperature result in economic losses in broiler production with negative effects on posthatch performance and slaughter yield (12,13). Research has clearly shown that higher temperatures during certain incubation periods have negative impacts on organ development (14), embryo development, chick quality (15,16), and broiler growth performance (17). However, research investigating the effects of abnormal incubation temperatures on slaughter weight, carcass yield, and meat quality is limited (18,19). Therefore, the current study was aimed to investigate the effects of higher setter and hatcher temperatures on slaughter weight and carcass yield.

2. Materials and methods

The care and use of animals was in accordance with the laws and regulations of Turkey and approved by the ethics committee of Uludağ University (License Number 2012-01/02 and License Number 2013-15/01).

In experiment 1, eggs were obtained from a commercial Cobb 500 flock at 35 weeks of age for two setter temperature groups (control and high setter temperature). All eggs were incubated in same incubator at 37.5 °C and a relative humidity of 55%–60% during the first 10 days of incubation. On 10 day of incubation, the eggs were separated into two groups and incubated in fully automated, programmable incubators. The setter

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temperature was maintained as control setter temperature and high setter temperature within the ranges of 37.8–38.2 and 38.9–40.0 °C, respectively. On the 18th day of incubation, the eggs were transferred to a hatcher. The hatcher was maintained at 36.8–37.0 °C and 70% relative humidity during hatching.

In experiment 2, eggs were obtained from a commercial Cobb 500 flock at 42 weeks of age for two hatcher temperature groups (control and high hatcher temperature). All eggs were incubated in the same incubator at 37.5 °C and a relative humidity of 55%–60% during the first 18 days of incubation. On the 18th day of incubation, the eggs were candled, and viable eggs were randomly divided into two groups and placed into hatching baskets. The eggs were then transferred to two hatcher cabinets for the following hatcher temperatures: control hatcher temperature (36.8–37.0 °C) and high hatcher temperature (38.8–39.0 °C).

A total of 240 chicks (120 males/120 females) from each experiment were randomly selected after the hatching process was completed. The chicks from the two experiments were placed in 12 floor pens with a surface area of 2.0 × 2.0 m2 to provide 40 chicks (20 males and 20 females). The chicks were weighed using a balance with ±0.1 g precision on the first day of the growing period. Wood shavings laid at a thickness of 8–10 cm on the floors of the pens were used as litter material. The chicks received a standard pelleted broiler starter diet (22.5% CP and ME 12.8 MJ/kg of diet) between days 1 and 14, a grower diet (22.0% CP and ME 13.3 MJ/kg of diet) between days 15 and 28, and a finisher diet (21.0% CP and ME 13.5 MJ/kg of diet) between days 29 and 42. Feed and water were offered ad libitum during the growing period. The chicks were exposed to 24 h of light at the first week and then 23 h of light and 1 h of darkness until the end of the experiment. Room temperatures were 33 °C at 1 day of age and decreased gradually by 3 °C/week until they reached 20 °C. Room temperature was then maintained at 20 °C with 50%–60% relative humidity until the end of the experiment.

Feed was withdrawn 12 h before slaughter at 42 days of age. A total of 60 broilers (30 males and 30 females) from each treatment in the two experiments (a total of 120 broilers for each experiment) were individually weighed to determine slaughter weight and then were slaughtered in the processing plant of the university farm. After slaughter, the carcasses were preserved by immersion in water with crushed ice for 3 h and then the carcasses were weighed. The carcass weight was measured after removing the head, feet, feathers, blood, and organs except lungs and kidneys. The carcass yield was calculated as a percentage of slaughter weight. Abdominal fat and the organs (heart, liver, gizzard, spleen) were individually weighed. The carcasses were then divided into pieces as wing, breast, neck, thigh, and drumstick according to the method described by the regulations on poultry meat quality (20). The thighs and drumsticks were carefully separated from the carcass above the thigh, towards the hip joint and behind the pubic bone. The drumsticks were then separated from the thighs by perpendicularly cutting the joint between the drumstick and thigh bones. The wings were removed by shoulder sectioning through the surfaces of the scapula and the coracoid joint. The breast was separated by perpendicularly cutting the ventral joints of ribs with the "rib" incision (21). The carcass pieces were then weighed and calculated as percentage of carcass weight.

Slaughter weight, carcass weight, carcass yield, weight and percentages of carcass pieces, abdominal fat pad, and organ weights were subjected to one-way variance analysis (ANOVA) (22). Significant differences among treatment means were determined by Tukey's test. Data are presented as mean ± SE. In all cases, a difference was considered significant at $P < 0.05$.

3. Results

The effects of the different setter temperatures during 10–18 days of incubation (experiment 1) and different hatcher temperatures (experiment 2) on the slaughter weight and carcass yield are presented in Table 1. In experiment 1, the slaughter weight was higher in the control group with a

Table 1. The effects of high setter and hatcher temperatures during incubation on slaughter weight, carcass weight, and carcass yield.

Characteristics	Experiment 1			Experiment 2		
	Control	High	P-value	Control	High	P-value
Slaughter weight (g)	2861.0 ± 140.7 a	2482.0 ± 208.7 b	0.00	2529.2 ± 185.5	2436.0 ± 275.4	0.130
Carcass weight (g)	2245.5 ± 140.7 a	1942.8 ± 208.7 b	0.00	1823.4 ± 188.8 a	1689.0 ± 173.5 b	0.001
Carcass yield (%)	78.48 ± 1.26	78.27 ± 2.06	0.425	72.10 ± 2.46 a	69.33 ± 5.34 b	0.020

a, b: Means ± SEMs in rows with different letters differ significantly ($P < 0.01$; $P < 0.05$). A total of 60 broilers (30 males and 30 females) from each group in each experiment were randomly sampled for measurements.

value of 2861.0 g compared to the high setter temperature group with a value of 2482.0 g ($P < 0.01$). Higher carcass weight was seen in the control group (2245.4 g) than the high setter temperature group (1942.8 g) ($P < 0.01$). The carcass weight and carcass yield were higher in the control group than the high hatcher temperature group ($P < 0.01$, $P < 0.05$), whereby the carcass weight was 1832.4 and 1689.0 g and carcass yield was 72.10% and 69.33% in the control and high hatcher temperature groups, respectively.

The effects of the different setter temperatures during 10–18 days of incubation (experiment 1) and different hatcher temperatures (experiment 2) on the weight and percentage of carcass pieces are presented in Table 2. In experiment 1, the weight and percentage of wings was higher in the control at 220.78 g and 10.10%, respectively ($P < 0.01$). The breast weight was also higher in the control group with a value of 981.4 g; however, the percentage of breast was higher in the high setter temperature group at 45.59% ($P < 0.01$). Similarly, the neck weight was found to be higher in the control group, but the percentage of neck was higher in the high setter temperature group ($P < 0.01$). A significant difference was observed for the thigh and drumstick weights ($P < 0.01$). A higher thigh weight, with a value of 545.12 g, was found in the control group as compared to the high setter temperature group, with a value of 386.74 g. The drumstick weight was higher in the control group at 371.55 g than in the high setter temperature group at 316.42 g. In experiment 2, the wing weight was higher in the control group with a value of 181.0 g as compared to the high hatcher temperature group with a value of 171.0 g ($P < 0.01$). The breast and neck weights were found to be higher in the control group ($P < 0.01$). The breast weight was found as 789.17 and 728.67 g and the neck weight as 114.67 and 101.33 g in the control and high hatcher temperature groups, respectively. Similarly, higher weights of thigh and drumstick were found in the control group with values of 382.16 and 312.67 g, respectively ($P < 0.05$).

The effects of the different setter temperatures during 10–18 days of incubation (experiment 1) and different hatcher temperatures (experiment 2) on the organ weights are presented in Table 3. In experiment 1, the heart, liver, and gizzard weights were similar, but the spleen weight was higher in the high setter temperature group (3.85 g) than the control group (3.41 g). In experiment 2, whereas the heart and liver weights were found to be significantly different in the groups ($P < 0.05$), the gizzard and spleen weights were similar. The heart and liver weights were higher in the control group, with values of 10.60 and 58.65 g, than in the high hatcher temperature group with values of 9.90 and 54.26 g.

Table 2. The effects of high setter and hatcher temperatures during incubation on weights and percentages of carcass pieces.

Characteristics	Experiment 1			Experiment 2		
	Control	High	P-value	Control	High	P-value
Weights of carcass pieces (g)						
Wing	220.78 ± 13.61 a	178.34 ± 18.12 b	0.00	181.0 ± 4.70 a	171.0 ± 15.09 b	0.001
Breast	981.4 ± 78.7 a	865.8 ± 94.0 b	0.00	789.17 ± 39.29 a	728.67 ± 72.73 b	0.00
Neck	173.19 ± 13.89 a	152.78 ± 16.58 b	0.00	114.67 ± 16.27 a	101.33 ± 11.50 b	0.001
Thigh	454.12 ± 30.25 a	386.74 ± 47.04 b	0.00	382.16 ± 45.75 a	354.93 ± 44.43 b	0.023
Drumstick	371.55 ± 24.83 a	316.42 ± 38.49 b	0.00	312.67 ± 37.43 a	290.40 ± 36.35 b	0.023
Abdominal fat pad	44.5 ± 2.4	42.8 ± 2.6	0.200	43.7 ± 2.4	42.7 ± 2.1	0.300
Percentages of carcass pieces (%)						
Wing	10.10 ± 0.62 a	9.41 ± 0.38 b	0.00	10.22 ± 0.69	10.42 ± 0.47	0.197
Breast	44.54 ± 1.49 b	45.59 ± 1.0 a	0.002	44.45 ± 1.99	44.30 ± 1.16	0.727
Neck	7.86 ± 0.26 b	8.05 ± 0.18 a	0.002	6.43 ± 0.68	6.17 ± 0.50	0.095
Thigh	20.64 ± 0.70	20.34 ± 0.61	0.077	21.40 ± 1.21	21.51 ± 0.54	0.631
Drumstick	16.90 ± 0.57	16.62 ± 0.49	0.051	17.51 ± 0.99	17.60 ± 0.44	0.631

a, b: Means ± SEMs in rows with different letters differ significantly ($P < 0.01$; $P < 0.05$). A total of 60 broilers (30 males and 30 females) from each group in each experiment were randomly sampled for measurements.

Table 3. The effects of high setter and hatcher temperatures during incubation on organ weights (g) (mean ± SEM).

Characteristics	Experiment 1			Experiment 2		
	Control	High	P-value	Control	High	P-value
Heart	12.86 ± 1.58	12.50 ± 2.54	0.516	10.60 ± 1.19 a	9.90 ± 1.25 b	0.030
Liver	55.17 ± 6.61	55.72 ± 9.73	0.799	58.65 ± 7.71 a	54.26 ± 9.16 b	0.049
Gizzard	70.08 ± 8.59	67.46 ± 8.52	0.241	49.53 ± 4.93	48.85 ± 6.12	0.636
Spleen	3.41 ± 0.84 b	3.85 ± 0.65 a	0.027	2.78 ± 0.35	2.62 ± 0.65	0.224

a, b: Means ± SEMs in rows with different letters differ significantly ($P < 0.01$; $P < 0.05$). A total of 60 broilers (30 males and 30 females) from each group in each experiment were randomly sampled for measurements.

4. Discussion

It is well known that fluctuations in incubator temperatures negatively affect posthatch broiler performance (12,13) and result in economic losses in broiler production. During incubation, abnormal temperatures affect bone (23), muscle (4), and organ (5) development and embryo development, chick quality (15,16,24) and broiler growth performance (17). Between days 10 and 18 of incubation, higher setter temperature resulted in a decrease in slaughter and carcass weight. In the case of deviation from optimum incubation temperatures, the development of organs and growth are supressed (25) and this is reflected in broiler performance during the growing period and eventually processing yield as broiler final product. In this study, the carcass weight was higher in the control compared to the high hatcher temperature group. During certain time periods of incubation, high incubation temperatures resulted in a decrease in carcass yield. Joseph et al. (2006), however, found that high temperature during hatching period had no effects on slaughter weight at 42 days of age. Studies that reported that high temperatures did not affect the slaughter weight and carcass weight are also available (17,19). Hulet et al. (19) found a similar slaughter weight at control (38.6 °C) and high (39.7 °C) temperatures between days 16 and 21 of incubation with values of 2176 and 2095 g, respectively.

High setter temperatures reduced the wing, breast, neck, thigh, and drumstick weights, but not that of the abdominal fat pad. However, the percentage of breast meat was found to be approximately 1% greater in the high setter temperature group. This may be related to increase in proliferation and accelerated differentiation of muscle cells after high temperature during the development period (26). This finding was in agreement with Molenaar et al. (17), who showed that the percentage of breast meat was higher at 30.7% with high temperature (38.9 °C) between days 7 and 21 of incubation as compared to normal temperature (37.8 °C) with a value of 29.7%. Observed differences in weights of carcass pieces may arise from differences in carcass weights of the groups.

In the present study, it was found that high temperatures affected some organ weights. The high setter temperature increased the spleen weight, whereas high hatcher temperature decreased the heart and liver weights. These findings may be attributed the negative effects of abnormal incubation temperatures on organ development during incubation. Thus, some studies showed that incubation temperatures above 37 °C during incubation can negatively affect development of the whole chicken and specific organs (27,28). Deficiencies in development of organs and embryos during incubation have an influence on chick development at hatching and consequently posthatch broiler performance and carcass yield.

In conclusion, deviations from optimum incubation temperatures during any time of incubation negatively affected the slaughter and carcass yield. Especially in large-scale broiler production, the quality and amount of broiler meat has great importance for producers' profitability. However, studies investigating the effects of abnormal incubation temperatures on slaughter processing yield, carcass characteristics, carcass defects such as skeletal or muscle problems, and meat quality are limited. Therefore, determination of the effect of incubation temperatures on these parameters may be beneficial for broiler production management and slaughterhouse processes. In that respect, more detailed studies taking account of different incubation conditions are needed to define the effects of these conditions on carcass yield and meat quality characteristics.

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