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The effects of thermal manipulation during the late incubation period on hatching traits and production performance in broilers.

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Abstract

This study, conducted over 56 days from November 3 to December 29, 2024, examined the effects of thermal manipulation during late incubation on hatching traits, chick quality, and post-hatch performance in Ross 308 broilers. The work began at Almiass's private hatchery and continued at Sulaymaniyah University's College of Agricultural Engineering Sciences. The study involved 750 eggs across five groups. Until day 18, all eggs were incubated at 37.5°C with 60–65% humidity. From days 19–21, one control and four thermally manipulated groups continued at 37.5°C and 70–75% humidity, with Thermal manipulation groups exposed to 6-hour daily cycles at varying temperatures (36.5°C, 35.5°C, 38.5°C, and 39.5°C) before returning to the baseline. Key parameters assessed included hatchability, embryonic mortality, chick quality, growth, feed intake, feed conversion ratio, and carcass traits. Higher incubation temperatures—especially 39.5°C—reduced hatch time but negatively affected hatchability and increased late embryonic mortality. Two indicators of chick quality were observed: the chick length was greater in the T0 group compared to the T4 group, while the T4 group exhibited a higher malformation rate than the T0 group. Even though the feed intake of all Thermal manipulation groups was significantly higher than that of the control, the 35.5°C group gained the most body weight after hatching. There were no appreciable changes in either the production index or the cumulative Feed conversion ratio. While the percentages of thighs and wings were the same, the 39.5°C group's breast output rose. Overall, Thermal manipulation had an impact on a few hatching and performance parameters.

Key words: Thermal Manipulation (TM), Hatchability, Embryonic Mortality, Growth Performance, Ross 308.

I. Introduction

Every day, the world needs more poultry meat and other by-products, and poultry is an important source of protein (Albashr et al., 2024; Khidhir, 2023; Faraj, 2023). The chicken is one of the most significant birds for making meat and eggs, which are important for the growth of industry and the economy. Growing populations and the growing demand for white meat, especially chicken, which is high in protein, all over the world (Ahmed et al., 2022; Hamma et al., 2024). Over the next 20 years, this means that the amount of poultry meat is predicted to go up by 60%. It is anticipated to be the most popular type of meat in the world by 2030 (Chan et al.,2021).

Changes in the poultry industry have had an effect on the incubation sector, nevertheless (Molenaar et al., 2010). Animal husbandry and welfare have been put in a very difficult position lately because of global warming, which is causing temperatures throughout the world to rise. This is a huge environmental threat to the whole world. One of the many things that make birds grown in commercial settings stressed out is changes in the temperature around them (Goel, Ncho et al., 2023). Due to this, researchers and producers need to keep looking for the ideal conditions for incubation. hence better incubation will make chickens develop faster and be more productive (Archer and Mench, 2014). Changes in incubation temperature can affect the growth of the embryo, the development of its organs, its metabolic rate, its physiological development, and its chances of hatching (Yalcin and Siegel 2003). A previous study found that incubating embryos at high or low temperatures made them more able to handle hot or cold weather. The conditions of

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incubation have a big impact on the quality of the chick, how it develops as an embryo, how well it hatches, and how well it does after hatching (Han, Li et al.,2022).

Researchers have suggested that changing the temperature at the end of incubation may have an effect on the embryo (Yildirim and Yetisir 2004). Al-Zhgoul et al., (2013), ($P<0.05$) that broilers that are stressed by temperature during these times are more likely to become thermotolerant later in life. Changes in gene expression caused by changes in incubation temperature might cause phenotypes to shift depending on the environment (Monaghan et al., 2008). Also, by changing the temperature of the incubation, broiler chicks can get used to fluctuations in the temperature around them after they hatch without using any energy while they are being raised (Collin et al., 2007). This study looked at hatching parameters, chick quality, growth performance after hatching, and carcass traits at 35 days of age to find out how heat modification affects embryogenesis during late incubation. The temperature treatment was greater and lower than the normal incubation temperature for six hours every day.

II. Materials and Methods

The study was carried out at the Almias private hatchery, which is situated on the main route between Sulaimani and Peramagrun. The chicks were then taken to Bakrajo Agricultural College in the Kurdistan area of northern Iraq after hatching. The study took place between March 11 and December 29, 2024, and the data was gathered in November and December of the same year. Investigating how late-incubation heat modulation affected hatching characteristics and post-hatch growth performance was the aim of the study.

Incubation period

The Ross-308 broiler breeder flock had 750 hatching eggs when they were 35 to 40 weeks old. Before putting the eggs in the incubator, they were weighed. The weight ranged from 52.8 to 53.5 g, with an average of 52.9 g. After they were collected, each egg was put in a van that was set up for the trip to the hatchery. After that, five identical Pas Reform incubators were utilized. They could hold up to 50600 eggs. After randomly splitting the chosen eggs into 25 trays with 30 eggs each, five copies were randomly assigned to each treatment group, which included the control group and four thermal treatment groups. During the incubation period (0–18 ED), all treatments were kept at the normal temperatures of 37.5°C and 60–65% relative humidity. The robots' built-in sensors automatically and accurately turned the eggs 90 degrees every hour. During the last three days of hatching (19, 20, and 21), the eggs were divided into five experimental groups, each with 150 eggs and different incubation temperatures: control group T0 (37.5°C), T1 (36.5°C), T2 (35.5°C), T3 (38.5°C), and T4 (39.5°C). All groups except the control group were exposed to thermal manipulation with the same relative humidity (70–75%) for six hours every day until they hatched. At 487 hours of incubation, the hatcher was opened for the first time, and every 6 hours after that, the time it took for the chicks to hatch was recorded. The chicks were put in boxes with copies of each treatment when they hatched on day 21. We counted the number of hatched chicks, including normal, weak, abnormal, and dead ones. We also opened all the unhatched eggs to see which ones were viable and to guess how far along the embryos were in dying based on how many times they had been replicated. The chicks that were killed were either weak or different from the others, whereas the other chicks were considered normal. We used an electric digital scale that was accurate to within ± 2 grams to weigh the day-old chicks in each replicate. Then we found the average weight of each chick. We figured out the percentages of culling, normal, early, medium, and late embryonic death, chick length, and hatchability (both total and fertile). During the trial, the cleanliness of the hatchery was thoroughly watched. Before being shipped to the farm, the chicks were given shots of the IB, Bf, and Newcastle vaccines.

Rearing period

Five hundred (500) day-old hatched chicks (Ross-308) were raised in the Animal Science Department's poultry research hall at the University of Sulaymaniyah's College of Agriculture from November 25 to December 29, 2024. There were twenty-five floor cages (1.50 x 1.50 m^2) in the house. Each treatment group's five replicates were randomly selected from among the chicks in that group. With Formalin, the house and its furnishings vanished. The housing was set up to guarantee ideal humidity, light, ventilation, and temperature for a full day prior to the arrival of the birds.

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Water and feed were manually administered during the study period. During the first seven days of life, a plastic feeder in a circular plate was employed, and a sufficient number of manual drinkers were used to provide water. Each pen was then equipped with two tube-type feeders (made of plastic cylinders that could hold 20 kg of grain) and one automatic hanging waterier in the form of a bell drinker. Water and food were given freely during the experiment. The ready-made feed came from Sulaiymaniyah's Super Feed Factory.
Following hatching, they received a vaccination via neck injection and a six-hour infusion of a sugar-water mixture. Medication, including vitamins and antibiotics, was given when it was due. The age of the birds and the vaccination technique were used to vaccinate the chicks. When drinking water was used for vaccination, the birds were thirsty three or four hours prior to the vaccination to ensure that all of the chicks had taken the medication. Two hens from each replication were chosen at random for killing on day 35.

Statistical analysis

We used SAS PROC GLM (version 9.4; SAS Institute Inc.) to do a least squares ANOVA on all the data. The cage for the broilers was thought of as a random variable, while the treatment was thought of as a fixed effect. The data is shown as the least squares mean plus or minus the standard error of the mean. A 5% chance ($P < 0.05$) was utilized to figure out if something was important.

III. Results and Discussion:

Table 1 indicates that all treatment groups had significant differences ($P<0.05$) in hatching time (hour), with T4 and T3 having the lowest hatching time values relative to the other groups and T2 and T1 having the highest hatching time values. These findings might be explained by the way incubation temperature speeds up the cell division of embryonic systems, which promotes embryonic development. By changing respiration rate, tissue metabolism, and embryonic growth, they also noted that a temperature higher than normal can increase embryonic weight. Such an increase can result in a shorter incubation period and easier eggshell breaking (Morita, Boleli, and Oliveira 2010; Badran et al., 2012; Piestun, Druyan et al., 2013; Han, Li et al., 2022). Additionally, the thyroid hormones (T3 and T4) are crucial for hatching and may be affected by temperature changes during incubation (Ismail et al., 2016). They affect the metabolism of the embryo, the maturation of the final tissue, and the physiological integration of the hatching process (Rippamonti and Dzialowski 2023). These findings concurred with those of Jabbar, Asim et al., (2020), who demonstrated that hatching can be postponed by manipulating the temperature during late incubation by lowering the incubation temperature. After day 15, the temperature was manipulated to be 3°C and 2°C lower than the standard incubation temperature for 5 days. The temperature was then raised by 1.5°C and 1°C, respectively, until hatching, which caused a 12-hour delay. (Iraqi, Hady et al., 2024) demonstrated that the pipping time was shorter at 37.5°C than the eggs set under 36.5°C. Current research indicates that from the 12th to the 18th days in the incubator, raising the incubation temperature to 39.5°C with 60% relative humidity for 4 hours each day enhanced a few hatching characteristics, including hatching time and pipped eggs.

Hatchability in There was a big difference ($P < 0.05$) between the control (T0) group and the T4 group in Table 1, but there were no big changes between the other treatment groups. These results could be because the high temperature speeds up the growth of the embryo and its need for oxygen. The embryo burns more oxygen, which makes more waste heat, which raises the temperature of the eggs even more. This, in turn, speeds up metabolism and makes the embryo need more oxygen. As a result, the embryo doesn't grow as quickly, can't fully use albumen proteins, is under a lot of stress, and the eggs don't hatch as well (Lourens 2003). The temperature of the incubation period may have an effect on the hatchability of the eggs because it affects the length of the incubation period and the amount of water that is lost during incubation. But these impacts rely on how long and how strong the shift from the best temperature is (Nakage, Cardozo et al., 2003).
These results were in line with what Tzschentke and Halle (2010), that raising the incubation temperature by 1°C for both the long and short term during the last 4 days of incubation had no effect on hatchability. For the higher temperature

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used in the treatment group (T4), it was in line with what Al-Zhgoul et al., (2013), and Collins (2013) found: that raising the temperature of chicken eggs by 1°C above standard during embryogenesis (ED10–18 and 18–21) reduced the hatchability of the total egg.

It was observed that the control group (T0) outperformed the group T4 in terms of normal chick rates. There were no significant differences observed among the other treatment groups. These results may be because keeping embryo temperatures at the right levels leads to healthier chicks, as the embryos take in more yolk and close their navels better, which lowers the chances of dying in the first week due to less navel/yolk sac issues and E. coli infections (Meijerhof 2003). These findings were consistent with Dhahir (2016), who hypothesized that heat-stressed embryos were typically weaker (based on the number of cull chicks), but only in birds thermally exposed at temperatures over 40.6°C.

For the chick length that showed in Table 1, The chicks in the TM group, especially the T4 group, were much shorter than those in the control group. There were no big differences between the different TM therapy groups.and these results are in agreement with (Amjadian and Shahir 2020).Also, (Sözcü and İpek 2013), Reported that lower temperatures than control caused shorter chick length compared to control. This result supports our results. Maybe at the control temperature, the embryo gets the right balance of metabolic activity, nutrient absorption, and cell division, allowing the chick to grow to its full potential before hatching.

Table 1: Effects of thermal manipulation during late incubation on hatching parameters and chick quality.

treatment	Hatching. T/ h	Hatchability%	Deformity rate%	Chick. L/ cm
T0	502.00±0.89 c	92.75±3.03 a	0.00±0.32 a	17.04±0.10 a
T1	507.40±0.89 d	87.80±3.03 ab	0.40±0.32 ab	16.82±0.10 ab
T2	511.00±0.89 e	87.96±3.03 ab	0.60±0.32 ab	16.48±0.10 b
T3	497.20±0.89 b	84.38±3.03 ab	0.60±0.32ab	16.49±0.10 b
T4	490.20±0.89 a	83.70±3.03 b	1.00±0.32 b	16.51±0.10 b
L.S	*	*	*	*

a, b, c: Within the same row, means ± SE with different superscripts differed significantly ($p<0.05$).

In table (2), there were no significant differences between all treatment groups for early and midterm mortality during the incubation period. However, there was a significant difference ($P<0.05$) between T4 and all other groups for late mortality. T1 had no significant difference with T4.

These findings could be attributed to the fact that embryonic mortality was much higher in the extremely high incubation profile. These results are consistent with those reported by Gonzales (2021), who found that temperature has the greatest influence on embryo mortality during the last incubation period. Eggs incubated at excessively high temperatures produced more deformed embryos. These findings are consistent with previous reports (Noiva, Menezes, and Peleteiro 2014; Tesarova, Skoupa et al., 2021). Joseph, Lourens, and Moran Jr. (2006), agreed with the findings of this study, finding no significant differences in early and intermediate embryonic mortality percentages between all thermally manipulated groups and the control group, and Iraqi, Hady et al. (2024) compared commercial setter temperatures for eggs (G1) and G2 during incubation. G1 was held at 37.5°C with 55% RH, while G2 was kept at 39.5°C with 60% RH for 4 hours every day. From the 19th to the 22nd day of incubation, all eggs were held at 37.2°C with 70% relative humidity. They also concluded that incubation temperature has no effect on embryonic mortality during days 1-7 and 8-15, whereas (Lourens, Van den Brand et al., 2005, Collins 2013) concluded that embryonic mortality was higher when hot treatment (38.9°C) was used compared to the control group (37.5-37.8°C) during 18-21 days of incubation, implying that incubation temperature influences embryonic growth rate and mortality.

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Table 2: Effects of thermal manipulation during late incubation on embryonic mortality.

treatment*	Early embryonic mortality (%)	Mid embryonic mortality (%)	Late embryonic mortality (%)
T0	0.40±0.24	0.40±0.30	0.60±0.38 a
T1	0.20±0.24	0.60±0.30	1.20±0.38 ab
T2	0.60±0.24	0.80±0.30	1.00±0.38 a
T3	0.60±0.24	0.80±0.30	1.00.38 a
T4	0.40±0.24	0.60±0.30	2.20±0.38 b
L.S	N. S	N. S	*

a, b: Within the same row, means ± SE with different superscripts differed significantly ($p<0.05$).

Table (3) demonstrated that there were no big changes in live body weight (BW/g) between any of the treatment groups when the animals were 35 days old.These results may be due to that the broilers were able to compensate from 3 weeks onwards which (Du Preez 2007),Reported that incubation temperatures of 36.6 and 39.5°C resulted both in low body weight and performance of broiler chickens to 3 weeks and these results were in agreement with (Al-Zghoul and El-Bahr 2019),which showed that there were no significant differences among short-term warm stimulated (4d, 2h ± 1°C as compared to each other and to the control group in body weight in accumulative BW (35 day).

Thermal modification had a substantial ($P<0.05$) effect on body weight gain in accumulative BWG/g (1-35 days) during the last days of incubation. The T2 treatment group outperformed all other groups, whereas T1 and T0 had no significant differences and had higher values than the T4 and T3 groups, which also had no significant differences. These findings could be attributed to the fact that chronic heat exposure has been linked to a reduction in the size of the gastrointestinal tract, as well as reduced digestive capacity; thus, a reduction in body weight gain was observed in high thermally treated groups (Mohammad and Sardary 2016). Furthermore, the difference in weight gain between treated groups could be attributed to different environmental conditions in the hatcher, which could result in different chick physiology at hatch and at the typical time of chick collection (day 21.5 of incubation), as well as different post-hatch growth (van de Ven 2012). These findings were consistent with Dhahir (2016), who found that decreasing food intake, in addition to reducing intestinal absorption and inducing gastrointestinal lesions, contributed to the lower BWG observed in birds kept under heat stress compared to those kept in a thermoneutral environment.

Table 3 There were big differences in cumulative feed consumption/g (1–35 days) between groups. The high-temperature manipulated treatment group, T4 and T3, had a better value than the other groups, while the low-temperature manipulated treatment group, T2 and T1, had a better value than the control group. One possible reason for the decrease in feed intake in heat-treated groups could be the influence of metabolic heat production, which is one of the factors that leads birds to eat less when they are kept in hot conditions (Oliveira Neto, Oliveira et al., 2000 and Siqueira, Oliveira et al., 2007).

Furthermore, because the chickens were kept at higher temperatures, they most likely increased their respiratory rate, reducing the time it took for them to consume feed (Aengwanich 2007 and Han, Zhang et al., 2010). Furthermore, an increase in serum corticosterone levels may have reduced food intake since corticosterone operates in the hypothalamus, where it regulates food intake and satisfaction upon ingestion, allowing for a decrease in consumption (Quinteiro-Filho, Ribeiro et al., 2010). (Meteyake, Bilalissi, et al., 2023) found that using higher temperatures than the control temperature during incubation increased daily feed intake in the control group compared to the heat-modified group during the rearing period, which is consistent with our findings.

Thermal manipulation during late incubation had no significant influence ($P\leq0.05$) on accumulative FCR (1-35 days) as compared to other treatment groups. These findings could be attributed to the proportions of weight gain and feed intake among all groups throughout the same 35-day raising period. This study's findings were consistent with those of Halle and Tzschentke (2011), there were no significant variations in FCR between the treatment and control groups at (1-35) days across the various rearing weeks. Furthermore, the results were supported by the findings of Dhahir (2016) and Mohammad and Sardary (2016), who found no significant differences in FCR in the accumulative FCR (1-35 days) between all thermally manipulated groups and the control group.

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Table (3) displays the production index for day 35. The results showed no significant changes between the treatment and control groups. As we all know, the higher the level of manufacturing efficiency, the better the technological performance. However, the improvement in the production index could be attributed to an overall improvement in broiler average body weight, mortality, and FCR percentage over the raising period. It could be because in our investigation, there were no significant differences in live body weight at 35 days of age between all thermally treated groups and the control group. Or the difference may be more noticeable at 42 days of age, when growth accelerates. may be connected to the mortality % throughout the entire raising period (1 to 35 days). While Halle and Tzschentke (2011) and Elmehdawi (2013) found that TM had no influence on broiler performance.

Table 3: Effect of thermal manipulation during late incubation on accumulative body weight (g), body weight gain (g/bird), feed consumption, feed conversion ratio and production index during rearing period (1-35 day) of broiler.

Treatment	Accumulative				
	BW (1 -35 d)	**BWG (1-35 d)**	**FI (1-35 d)**	**FCR (1-35 d)**	**PI 35 d**
T0	2064.44±6.97	2017.64±7.01 b	3141.92±10.56 c	1.55±0.035	369.83±25.74
T1	2077.80±6.97	2030.33±7.01 b	2898.66±10.56 b	1.43±0.035	414.06±25.74
T2	2108.68±6.97	2064.41±7.01 a	2892.48±10.56 b	1.39±0.035	414.78±25.74
T3	1989.18±6.97	1945.05±7.01 c	2851.56±10.56 a	1.45±0.035	363.64±25.74
T4	2050.40±6.97	2005.60±7.01 b c	2824.00±10.56 a	1.41±0.035	408.98±25.74
L.S.	N. S	*	*	N. S	N. S

a, b, c: Within the same row, means ± SE with different superscripts differed significantly ($p<0.05$).

Table (4) There are no big differences in carcass traits across the treatment groups, save for a big ($P\leq0.05$) difference between the T4 and T3 groups. The breast% value for T4 was higher than that for T3. When compared to the control group (ALI, Ibrahim, and AL Sardary 2019), using a temperature of 38.2°C for 4 hours on days 1–5 and 19–20 had no effect on thigh weight at slaughter age. This is similar with the results of T3 and T0. Our results back up Hulet, Gladys, and others (2007), who found that changing the temperature in 16 Ed at 37.5°C (low, L), 38.6°C (medium, M), and 39.7°C (high, H) worked. The temperature of the incubator did not cause any noticeable changes in the carcass traits. So, we can say that the results of our study's thigh and wing meat are in line with those of Fernandes et al., (2016). It

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was shown that changing the temperature during the last incubation period (16 to 19 days/4 hours a day) did not affect the quality or quantity of meat from male and female broilers.

Table 4: Effect of thermal manipulation during late incubation on carcass traits at age 35 days of broiler chicks.

Treatment*	Carcass traits		
	Breast%	Thigh%	Wings%
T0	35.69±1.00 ab	21.32±1.09	9.63±0.27
T1	35.92±1.00 ab	22.75±1.09	9.91±0.27
T2	36.23±1.00 ab	23.25±1.09	9.55±0.27
T3	35.05±1.00 b	23.26±1.09	9.58±0.27
T4	37.97±1.00 a	22.68±1.09	9.72±0.27
L.S.	*	N. S	N. S

a, b: Within the same row, means ± SE with different superscripts differed significantly ($p<0.05$).

IV. Conclusion and recommendation

Thermal manipulation during the late incubation stage altered several hatching and post-hatch performance parameters in broiler chickens.

1. Moderately lower incubation temperatures (35.5°C) increased body weight gain.
2. High temperatures (38.5°C and 39.5°C) significantly reduced hatchability and increased late embryonic mortality.
3. Chick quality traits, such as deformities and length, were significantly changed. The length of chicks was significantly lower in the T4 group compared with the control group. But the deformity rate in the T4 group is highered to the T0 group.
4. Feed consumption fell in all TM groups, possibly due to changed metabolic or stress adaptation mechanisms.
5: Despite variances in growth performance, we found no significant differences in the FCR or production index between treatment groups.
6. Carcass characteristics showed a small increase in breast muscle yield when temperatures were raised. highlighting possible benefits to meat production. In conclusion, cautious use of temperature manipulation can be a strategic strategy for increasing broiler output.

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