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Determination of ideal brooding temperature for broilers performance and welfare

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This study explores the determination of optimal brooding temperatures for broilers to enhance growth performance and welfare. Using a completely randomized design (CRD), 60-day-old broiler chicks were assigned to four different treatments: charcoal heat, electric bulb heat, ambient temperature, and local lamp combined with ambient temperature. Each treatment was replicated three times. Key parameters, including weight gain, feed conversion ratio (FCR), and mortality rates, were assessed over four weeks using JMP 15.0.0 statistical software. Results indicated significant variations among treatments in temperature stability, growth performance, and feed efficiency. Charcoal heat, maintaining an average temperature of 32.6°C, achieved the highest weight gain (944 g) and the most efficient FCR (1.28). The electric bulb heat source maintained an average temperature of 30.4°C, producing comparable but slightly lower outcomes in weight gain (915 g) and FCR (1.41). In contrast, ambient temperature conditions recorded the lowest average temperature (25.9°C), resulting in poor growth performance, the highest FCR (1.74), and the highest mortality rate (33.3%). The local lamp combined with ambient temperature achieved moderate results, reflecting intermediate performance metrics. These findings underscore the critical role of temperature regulation in broiler production, particularly during the early brooding phase when chicks are most vulnerable to temperature stress. Optimal temperatures between 30°C and 33°C, achieved with charcoal or electric bulb heating, significantly enhanced growth and feed efficiency while minimizing mortality. This study provides actionable insights for small- and large-scale poultry operations, particularly in resource-limited settings, where access to electricity or advanced heating systems may be constrained. The results emphasize the need for sustainable and efficient heating methods to improve broiler productivity and welfare in diverse farming conditions.

Keywords: Broilers**,** Brooding, Chicken, Temperature, welfare

INTRODUCTION

Broiler chickens are one of the fastest-growing segments of the poultry industry, providing a significant source of animal protein worldwide (Bell and Weaver, 2002). The brooding phase, which is the period from day-old chicks until they can self-regulate their body temperature (about 3 weeks of age), is critical to broiler productivity (Czarick and Fairchild, 2006). During this time, temperature management is key to ensuring optimal growth, feed efficiency, and overall health and welfare of the poultry (Donkoh, 1989). For instance, studies have shown that maintaining a stable brooding temperature reduces chick mortality by up to 30% in rural poultry setups (Thompson et al., 2017).

Brooding management involves creating a controlled environment with sufficient warmth to help chicks develop their thermoregulatory system, which is not fully functional during the first few weeks of life. Various heat sources are employed during this phase, including ambient temperature, electric bulbs, charcoal stoves, and local lanterns (Jones and Dawkins, 2010). The choice of heat source is crucial because it influences the microclimate in the brooding environment, affecting the poultry’s comfort, growth performance, and welfare. Proper heat management is critical, as noted by Wasti et al. (2020), to ensure consistent chick performance and welfare.

In developing countries, especially in rural areas where electricity may be unreliable or unavailable, alternative heat sources like charcoal stoves and local lanterns are often used (Bell and Weaver, 2002). While these sources can be effective, they may not provide the consistent temperatures that electric bulbs offer, leading to fluctuations that can affect chick performance (Yahav et al., 1995). Therefore, determining the ideal brooding temperature under different heat sources is essential to ensure both high productivity and animal welfare. These methods, while accessible, may compromise the uniformity of temperature control (Wilcox et al., 2023; Deaton et al., 1996). Alternative methods, such as the use of biomass-powered heaters, have also been explored to address this challenge (Kumar et al., 2023).

Brooding temperatures are critical for ensuring the health and growth of broiler chicks. Improper temperature regulation during the brooding phase can lead to poor growth, increased feed conversion ratio (FCR), high mortality, and compromised welfare (Donkoh, 1989). Many farmers in rural areas rely on traditional heat sources, such as charcoal stoves and local lanterns, due to the high cost or unavailability of electricity (Jones and Dawkins, 2010). However, these alternative heat sources may not provide the ideal conditions for optimal broiler performance. Research highlights that deviations from the ideal range of 32-34°C can lead to chronic stress, significantly impairing growth rates (Sesay, 2022).

Despite the growing use of electric bulbs in more urban settings for consistent temperature control, many rural farmers lack access to this option, relying on ambient temperature or more variable heat sources (Bell and Weaver, 2002). Understanding how these various heat sources impact brooding conditions and broiler outcomes is critical to improving productivity, reducing mortality, and enhancing welfare in these settings.

The main objective of this study was to determine the ideal brooding temperature for broiler performance and welfare under various heat sources.

METHODOLOGY

Study location

The experiment was carried out at the College of Agriculture and Animal Science, Division of Agricultural Colleges, Ahmadu Bello University, Mando Road Kaduna, located within latitude 10.35°N and longitude 7.42°E.

Experimental design

This study was conducted to determine the ideal brooding temperature for optimizing broiler performance and welfare using Completely Randomized Design (CRD) and Replicated three times. A total of 60-day-old broilers were randomly assigned to four treatments. The treatments are Charcoal heat source, Electric bulb heat source, Combination of lamp and ambient temperature and Ambient temperature alone.

Each treatment was assigned with equal number of day-old chicks, with all groups housed under similar environmental conditions to ensure consistency. Feed and water were provided ad libitum throughout the study.

Data Collection

Key data collected during the experiment included:

- Temperature Data: The temperatures of each treatment setup were measured thrice daily using calibrated thermometers.

- Weight Gain: Weekly weight gain was recorded for each broiler.

- Feed Conversion Ratio (FCR): Calculated as the ratio of feed intake to weight gain.

- Mortality Rate: Any deaths during the experiment were recorded.

Statistical Analysis

The data were subjected to one way analysis of variance and descriptive Statistics using JMP 15.0.0 statistical software. Furthermore, means were compared using Fisher’s Least Square Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

Impact of different heat sources on the growth performance chickens

Table 1 presents a comprehensive evaluation of the impact of different heat sources on the growth parameters of day-old chicks during brooding. The parameters measured include average temperature (°C), feed intake, weight gain (g), feed conversion ratio (FCR), and mortality (%). The treatments compared were charcoal, electric bulb, ambient temperature, and local lamp combined with ambient temperature (AT).

The recorded temperatures under different heat sources exhibited notable variations, with the highest average temperature observed in the charcoal treatment (32.6°C) and the lowest in the ambient temperature treatment (25.9°C) which is similar to the findings of Bello et al.; (2017). Charcoal’s ability to maintain a higher and stable brooding temperature likely contributed to its superior performance in promoting growth parameters. Conversely, the ambient temperature treatment provided significantly lower warmth, which is suboptimal for chicks, leading to negative growth outcomes of (Bello et al., 2017; Ragab et al., 1967). The electric bulb (30.4°C) and the local lamp combined with ambient temperature (28.9°C) demonstrated intermediate temperature levels, though both were lower than the charcoal treatment.

Feed intake was significantly influenced by the heat source, with the highest consumption recorded under ambient temperature (1492 g) and the lowest under charcoal (1210 g) which is agreement with the findings of Sogunle et al. (2018). This counter intuitive result can be attributed to the compensatory behavior of chicks exposed to colder environments, where they consume more feed to generate body heat (Hill and Wall, 2017). However, it is important to note that despite higher feed intake, the ambient temperature group did not translate this into optimal weight gain (Hill and Wall, 2017). The local lamp + AT (1405 g) and electric bulb (1289 g) treatments recorded intermediate feed intake levels, showing a consistent trend where lower temperatures led to higher feed consumption.

Weight gain, a critical measure of chick growth performance, was highest under the charcoal treatment (944 g) and lowest under the ambient temperature treatment (857 g) which is agreement with findings of Kutlu et al. (2001). This indicates that higher ambient temperatures provided by charcoal were conducive to better growth, likely due to reduced energy expenditure for thermoregulation (Odunsi et al., 2007). The electric bulb and local lamp + AT treatments exhibited moderate weight gains (915 g and 882 g, respectively). The significant differences in weight gain among treatments emphasize the importance of maintaining optimal brooding temperatures to maximize growth efficiency (Kutlu et al., 2001).

The FCR, representing the efficiency of feed utilization, followed a clear trend where the charcoal treatment exhibited the lowest FCR (1.28), indicating superior feed efficiency. In contrast, the ambient temperature group had the highest FCR (1.74), reflecting poor feed utilization (Bello et al., 2017). This inefficiency can be attributed to the high energy demands for thermoregulation in a colder environment. The local lamp + AT (1.59) and electric bulb (1.41) treatments had intermediate FCR values, reinforcing the trend that suboptimal brooding temperatures negatively affect feed efficiency (Sogunle et al., 2018).

Mortality rates were statistically non-significant across treatments, with charcoal and electric bulb groups showing the lowest rates (6.67%) and ambient temperature the highest (33.3%) which is in agreement with the findings of (Hassanuzzaman et al., 2004). The elevated mortality under ambient conditions underscores the critical need for sufficient external warmth during brooding. Interestingly, the local lamp + AT treatment showed a mortality rate of 13.3%, which, though higher than charcoal and electric bulb, was significantly lower than the ambient temperature treatment. This suggests that supplementation of ambient temperature with local lamps can improve survival rates (Kutlu et al., 2001).

Influence of heat source on the brooding temperature

Figure 1 illustrates the variations in temperature associated with different heat sources used during the brooding of day-old chicks. The heat sources evaluated include charcoal, electric bulb, ambient temperature, and local lamp combined with ambient temperature (AT). This highlight the critical role of external heating in maintaining optimal brooding conditions.

The data depicted in Figure 1 reveal distinct temperature differences among the heat sources. Charcoal produced the highest average temperature (32.6°C), which falls within the optimal range for brooding day-old chicks (Odunsi et al., 2007). This consistency in maintaining adequate warmth underscores the efficacy of charcoal as a heat source. In contrast, the ambient temperature treatment recorded the lowest average temperature (25.9°C), far below the recommended range for chick brooding. Such low temperatures are associated with increased energy expenditure by chicks to maintain their body temperature, leading to compromised growth and higher mortality (Zhou et al., 2021).

The electric bulb and local lamp + AT treatments provided intermediate temperature ranges, with averages of 30.4°C and 28.9°C, respectively. While these temperatures are closer to the optimal range compared to ambient temperature alone, they still lag behind charcoal in providing consistent warmth (Odunsi et al., 2007). This indicates that although these treatments offer some improvement over ambient conditions, they may not fully meet the thermal needs of chicks.

The differences in temperature among the heat sources have direct implications for chick performance (Odunsi et al., 2007). Higher temperatures, as achieved with charcoal, reduce the energy expenditure required for thermoregulation. This allows chicks to allocate more energy toward growth and development, resulting in higher weight gain and improved feed efficiency (Zhou et al., 2021).

Comparing weight gain from different heat sources

Figure 2 presents the comparison of average weight gain of chicks under different heat sources during the brooding period. The heat sources include charcoal, electric bulb, ambient temperature, and a combination of local lamp with ambient temperature (AT). The figure provides insights into how the varying thermal conditions of these treatments affect the growth performance of chicks.

The chicks exposed to the charcoal heat source achieved the highest average weight gain (Mramba and Mapunda, 2024), which aligns with the optimal brooding temperatures observed in Figure 1. This result can be attributed to the stable and adequate warmth provided by charcoal, which minimizes energy expenditure on thermoregulation and allows for efficient growth (Bello et al., 2017).

Conversely, the ambient temperature treatment recorded the lowest average weight gain. The suboptimal temperature conditions in this treatment likely forced chicks to utilize more feed energy for maintaining body heat (Wasti et al., 2020), thereby reducing the energy available for growth (Tumbach, 1920). This is consistent with findings in Table 1, which showed poor feed conversion efficiency under ambient temperature conditions.

Relationship between weight gain and average temperature during the brooding period

Figure 3 shows the relationship between average temperature and average weight gain during the brooding period. The figure presents a clear trend that highlights how variations in temperature influence the growth performance of chicks, serving as an essential tool for understanding the thermal needs of poultry during early development (Oluwagbenga and Fraley, 2023).

The data in Figure 3 demonstrate that weight gain is highly sensitive to changes in temperature. The highest weight gain is achieved at optimal temperature ranges, corresponding to conditions provided by the charcoal treatment as shown in earlier figures and tables. As temperatures deviate from this optimal range—whether too low or too high—average weight gain declines significantly (Wasti et al., 2020). This trend underscores the importance of maintaining consistent and appropriate thermal conditions during brooding.

At lower temperature ranges, such as those associated with ambient temperature conditions, weight gain is markedly reduced (Oluwagbenga and Fraley, 2023). This decline can be attributed to increased energy demands for thermoregulation, where chicks divert energy from growth to maintaining body heat (Oluwagbenga and Fraley, 2023; Wasti et al., 2020). Similarly, excessively high temperatures can lead to heat stress, which negatively impacts feed intake and, consequently, weight gain.

Relationship between feed conversion ratio of chickens and the average temperature during brooding

Figure 4 illustrates the relationship between the feed conversion ratio (FCR) of chickens and the average temperature during brooding. The FCR is a critical measure of efficiency in poultry production, representing the amount of feed consumed to achieve a unit of weight gain (Wasti et al.; 2020). By examining the interaction between FCR and temperature, this figure provides valuable insights into how thermal conditions influence the energy utilization and growth efficiency of chicks.

The data in Figure 4 reveal an inverse relationship between FCR and average temperature within an optimal range. As average temperatures increase from suboptimal levels, the FCR decreases, indicating improved feed efficiency. This trend reaches a plateau or optimal point within the ideal temperature range (approximately 30°C to 33°C), beyond which further increases in temperature result in a rise in FCR (Wasti et al.; 2020).

Influence of heat source on the mortality rate of brooding chicks

Figure 5 provides a visualization of the mortality rates across different treatments used during brooding. Represented as a pie chart, this figure highlights the proportion of mortality rates observed under charcoal, electric bulb, ambient temperature, and local lamp combined with ambient temperature (AT). These treatments recorded the lowest mortality rates, with each contributing a small proportion to the overall mortality. This indicates that these heat sources are effective in providing stable and adequate warmth, reducing the risk of temperature-related stress and mortality (Lin et al., 2006). The ambient temperature treatment accounts for the highest proportion of mortality. This outcome highlights the inadequacy of relying solely on ambient conditions to meet the thermal needs of chicks, particularly in regions with suboptimal environmental temperatures (Sesay, 2022). While the local lamp combined with ambient temperature showed improved mortality rates compared to ambient temperature alone, it still recorded a higher proportion of mortality than charcoal and electric bulb treatments. This suggests that supplemental heating, while beneficial, may not fully compensate for the lack of consistent warmth (Lin et al., 2006).

CONCLUSION

This research emphasizes the vital role of maintaining optimal brooding temperatures for broilers, particularly during early development when thermoregulation is immature. Among the heat sources tested, charcoal heat (32.6°C) proved most effective, ensuring stable warmth, the highest weight gain (944 g), and the best feed conversion ratio (FCR) of 1.28. Electric bulbs (30.4°C) showed comparable results, making them a viable option where electricity is available. In contrast, ambient temperature treatment yielded the poorest outcomes, with low temperatures (25.9°C), high mortality (33.3%), and reduced growth. The local lamp combined with ambient temperature offered intermediate results but failed to fully address thermal inconsistencies. These findings are particularly valuable for small- and medium-scale poultry farmers, especially in resource-limited areas. The study underscores the importance of effective heating systems like charcoal and electric bulbs to enhance productivity, welfare, and sustainability in broiler farming. Optimal temperature management can significantly improve feed efficiency, reduce mortality, and boost economic outcomes.

REFERENCES

Bell D.D., Weaver W.D. (2002). Commercial chicken meat and egg production (5th ed.). Springer Science and Business Media.

Bello I., Adekanmbi A., Basiru A., Jagun A. (2017). Effect of charcoal brooding on certain physiological parameters of cockerel chicks. Alexandria Journal of Veterinary Sciences, 52: 6.

Czarick M., Fairchild B.D. (2006). Poultry housing tips: Brooding tem peratures and chick performance. University of Georgia Cooperative Extension.

Deaton J.W., Branton S.L., Simmons J.D., Lott B.D. (1996). The effect of brooding temperature on broiler performance. Poultry Science, 75: 1217–1220.

Donkoh A. (1989). Ambient temperature: a factor affecting performance and physiological response of broiler chickens. International Journal of Biometeorology, 33: 259–265.

Hassanuzzaman Ahammad M.U., Bulbul S.M., Nurul Alam A.M. M., Islam M.A. (2004). A comparative study on the efficiency of locally made low cost brooders for brooding chicks. Asian-Australasian Journal of Animal Sciences, 17: 1586–1590.

Hill D.L., Wall E. (2017). Weather influences feed intake and feed efficiency in a temperate climate. Journal of Dairy Science, 100: 2240–2257.

Jones T.A., Dawkins M.S. (2010a). Effect of environment on behavior, welfare, and productivity of laying hens: A review. World’s Poultry Science Journal, 66: 469-478.

Jones T.A., Dawkins M.S. (2010b). Environment and management factors affecting welfare in broiler chickens. Poultry Science, 89: 903-911.

Kumar S., Tripathi A., Das S., Ghangrekar M.M. (2023). Biochemical approach for transformation of agricultural waste to bioenergy and other value-added products through the bioelectrochemical system. Agricultural Waste to Value-Added Products, 69–94.

Kutlu H.R., Ünsal I., Görgülü M. (2001). Effects of providing dietary wood (oak) charcoal to broiler chicks and laying hens. Animal Feed Science and Technology, 90: 213–226.

Lin H., Jiao H.C., Buyse J., Decuypere E. (2006). Strategies for preventing heat stress in poultry. World’s Poultry Science Journal, 62: 71–86.

Lopez J.A., Perez M., Torres R. (2016). Impact of suboptimal brooding temperatures on broiler physiology. Journal of Animal Science, 74: 258-266.

Mramba R.P., Mapunda P.E. (2024). Management factors associated with the survival and market weight of broiler chickens among small-scale farmers in the Dodoma City of Tanzania. Heliyon, 10: e33907.

Odunsi A.A., Oladele T.O., A. Olaiya O., Onifade O.S. (2007). Response of broiler chickens to wood charcoal and vegetable oil based diets. World Journal of Agricultural Sciences, 3: 572-575.

Oluwagbenga E.M., Fraley G.S. (2023). Heat stress and poultry production: a comprehensive review. Poultry Science, 102: 103141.

Ragab M.T., Ghany M.A., Sabry S.A. (1967). Effect of floor space, brooding temperature and type of brooding on the growth pattern of Fayoumi chicks. Egyptian Journal of Animal Production, 7: 23–32.

Sesay A.R. (2022). Impact of heat stress on chicken performance, welfare, and probable mitigation strategies. International Journal of Environment and Climate Change, 12: 3120–3133.

Sogunle O.M., Odutayo O.J., Osidina M.O., Safiyu K.K., Ogundele M.A. (2018). Effects of brooding heat sources on growth performance and cost of feed utilization of two strains of broiler chickens. Bulletin of Animal Health and Production in Africa, 66: 83-89.

Thompson A.K., Wilson J., Morgan D. (2017). Temperature dynamics in rural poultry systems. Livestock Science, 43: 90-97.

Tumbach J.H. (1920). Brooding and caring for baby chicks. https://doi.org/10.5962/bhl.title.58415

Wasti S., Sah N., Mishra B. (2020). Impact of heat stress on poultry health and performances, and potential mitigation strategies. Animals, 10: 1266.

Yahav S., Goldfeld S., Plavnik I., Hurwitz S. (1995). Physiological responses of chickens and turkeys to relative humidity during exposure to high ambient temperature. Journal of Thermal Biology, 20: 245-253.

Zhou H.J., Kong L.L., Zhu L.X., Hu X.Y., Busye J., Song Z.G. (2021). Effects of cold stress on growth performance, serum biochemistry, intestinal barrier molecules, and adenosine monophosphate-activated protein kinase in broilers. Animal, 15: 100138.

References