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Seasonal Impacts on Thermal Comfort and Growth Performance of Broilers in Commercial Conditions

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Abstract

This study was conducted on 12 broiler flocks (Ross 308) reared during the spring and autumn seasons on commercial farms in Bursa and its districts, in a contracted production model under an integrator firm. Broiler performance parameters, including final body weight, cumulative feed and water intake, and feed conversion ratio (FCR), along with environmental parameters such as temperature, relative humidity (RH), and CO_2 concentration, were monitored over a 42-day growing period. The Temperature-Humidity Index (THI) was calculated using average temperature and RH data. While body weight and feed intake remained consistent across seasons, FCR was more efficient in spring (1.38 vs. 1.53, $P<0.05$). The back-side temperature was higher in the spring than in the autumn (28.8ºC vs. 27.9ºC, $P<0.001$). The back size THI with a value of 80.1 was found to be higher in the spring compared to the autumn (78.4, $P<0.01$). The CO_2 concentration was found to be higher in the autumn (1801.1 ppm) than the spring (1415.1 ppm, $P<0.001$). These findings clearly showed that the season affects economic performance through FCR. Investigating the potential positive or negative effects of the seasons could provide crucial insights for developing new strategies to optimize flock management and improve welfare standards in broiler production.

Introduction

The investigation of thermal comfort and growth performance of broilers has garnered significant attention in the poultry industry, reflecting the critical role these factors play in optimizing production efficiency and animal welfare. Thermal comfort is a critical factor influencing the growth performance, welfare, and overall productivity of broilers in commercial poultry production. Broilers are particularly sensitive to environmental temperatures, and maintaining optimal thermal conditions is essential for their growth, feed efficiency, and health (Lara and Rostagno, 2013). The thermal comfort zone, typically between 18-22°C, supports optimal metabolic activity and growth rates, while deviations can lead to heat or cold stress, impacting growth performance (Sahin *et al.,* 2018). Heat stress, often encountered in commercial operations, disrupts metabolic processes, reduces feed intake, and impairs weight gain, leading to significant economic losses (Azad *et al.,* 2010).

The growth performance of broilers is highly dependent on maintaining a stable thermal environment. Proper management strategies, such as adequate ventilation, temperature control, and humidity regulation, are essential to optimize broiler performance and welfare (Nawab *et al*., 2018). A previous research shows that temperature management directly affects physiological responses, nutrient metabolism, and immune function, highlighting the importance of environmental control in broiler production systems (Lin *et al*., 2006). Therefore, understanding and managing thermal comfort are crucial for enhancing growth performance and ensuring sustainable and efficient poultry production. The thermal comfort and growth performance of broilers are critical factors influencing poultry production, particularly under commercial conditions where seasonal variations can significantly impact these parameters. Thermal comfort refers to the state where the environmental conditions allow birds to maintain their body temperature without excessive metabolic energy expenditure, which is crucial for optimal growth and welfare (Dedousi *et al.,* 2023; Franco and Alencar, 2022). As broilers are particularly susceptible to heat stress, understanding the interplay between seasonal changes and thermal comfort is essential for enhancing their performance and overall health (Purswell *et al*., 2012; Akter *et al.,* 2022).

A Previous research indicates that environmental factors such as temperature, humidity, and air velocity play a pivotal role in determining the thermal comfort of broilers (Akter *et al.*, 2022; Teles *et al.,* 2020). For instance, the Temperature-Humidity Index (THI) is commonly used to assess the comfort level of poultry, with higher THI values correlating with increased heat stress and reduced growth performance (Dedousi *et al.,* 2023; Purswell *et al.,* 2012). Studies have shown that broilers exposed to high THI conditions exhibit decreased feed intake and growth rates, highlighting the importance of maintaining optimal environmental conditions throughout different seasons (Dedousi *et al.,* 2023; Purswell *et al*., 2012). Furthermore, the design and management of poultry housing, including ventilation systems and insulation, are critical in mitigating the adverse effects of seasonal temperature fluctuations (Curi *et al*., 2017; Abreu *et al.*, 2011). The literature also emphasizes the importance of environmental management in maintaining thermal comfort for broilers. A Previous research has highlighted the effectiveness of climate control systems in poultry houses, which are crucial for sustaining optimal thermal conditions and minimizing stress during extreme weather (Teles *et al.,* 2020; Vieira *et al.,* 2010). Furthermore, studies have demonstrated that maintaining appropriate humidity levels and air circulation can significantly enhance the thermal comfort of broilers, leading to improved growth outcomes (Dedousi *et al.*, 2023). Moreover, dietary interventions have been explored as a means to enhance broiler resilience to thermal stress. For example, incorporating specific feed additives or adjusting protein levels in diets can improve growth performance and thermal acclimatization in heat-stressed broilers (Popoola *et al.,* 2020; Popoola *et al.,* 2021). The nutritional strategies employed during critical growth phases can significantly influence the birds' ability to cope with seasonal temperature extremes, thereby optimizing their overall productivity (Dedousi *et al.,* 2023).

The aim of this study was to assess the performance and environmental conditions of commercial broiler farms located in Bursa region. This study monitored a total of 12 broiler flocks during the Spring (March, April, May) and Autumn (September, October, November) seasons of 2021-2022, with 6 broiler flocks observed per season. Key performance metrics, such as final body weight, feed intake, water intake, and feed conversion ratio (FCR) were evaluated.

Material and Method

The current study was carried out on commercial broiler farms located in Bursa and its districts, following a contracted production model under an integrator firm. A total of 12 broiler flocks (Ross 308) were monitored in the same farm with two broiler houses (H1 and H2, Figure 1) during spring (March, April, May) and autumn (September, October, November) seasons in 2021-2022 (n: 6 broiler flocks/season). Poultry houses are fully environmentally controlled and PET panels are used for ventilation along with tunnel-type fans, ensuring negative pressure ventilation in the broiler houses. The characteristics of the broiler houses where the study was conducted are given in Table 1.

All flocks were kept in littered houses covered with rice hulls and equipped with automatic ventilation, heating, drinkers, and feeders. The production data including number of birds, live bird per m^2 and live weight per m^2 was given in Table 2. The management practices, including feeding (65-70 birds per pan feeder) and drinking (8 drinkers per 1000 birds) vaccination (Newcastle and infectious bronchitis on day 10, Gumboro on day 15, Newcastle on day 21), ventilation, stocking density, lighting (intermittent lighting schedule with 4 hours dark period) and health protection, were applied according to the management guide provided by breeding company (Aviagen, 2020). Each flock was fed commercial diets with similar composition, as feed formulation was standardized by the company.

Figure 1. The location of the broiler houses (Bursa, Turkey)

Tablo 1. General characteristics of the broiler houses

House	Breeding Type	Number of birds	Direction	House width (m)	House Length (m)
H1	Broiler	46000	N-S	32	80
H2	Broiler	46000	N-S	32	80

Tablo 2. Production information

House	Number of birds	Live bird per m^2	Live weight per m^2
Autumn 1	44000	17.19	49.45
Autumn 2	42080	16.44	46.73
Autumn 3	45950	17.95	50.83
Spring 1	42080	16.41	42.57
Spring 2	44000	17.19	54.19
Spring 3	44000	17.19	47.71

The birds were provided with commercial diets ad libitum: starter (between 1-10 days, 23% CP and 3000 kcal ME/kg), grower (between 11-21 days, 22% CP and 3100 kcal ME/kg), and finisher (between 21-42 days, 20.5% CP and 3200 kcal ME/kg).

Performance data included the final body weight, total feed intake, water intake and feed conversion rate (FCR). The final body weight was calculated as the averages of 10% of the flocks with random samples. All flocks were monitored using a computerized controlling system for feed and water consumption, with feed and water consumption were calculated as a ratio between feed or water consumption and the number of birds. FCR was expressed as the ratio between cumulative feed intake and body weight gain.

The temperature and relative humidity of the houses were recorded hourly and then presented as averages for each growing cycle using an automatic data logger (Testo 174H Data Logger, Pennsylvania, USA) throughout the growing period. Based on the measurements, Temperature-humidity Indices (THI) were calculated for each hour according to the equation described by Berman et al. (2016):

$$THI=3.43+1.058 \times T- 0.293 \times RH + 0.0164 \times T\times RH+35.7$$

where; T is temperature and RH is the relative humidity. The outdoor temperature data of the research area was obtained from the website "Weatherspark" (Anonymous, 2024). Figure 2 shows the outdoor temperature data at the location of the broiler houses.

The CO_2 concentrations were monitored hourly using an INNOVA 1314i photoacoustic multi-gas monitor (LumaSense Technologies A/S, Ballerup, Denmark). The data was given as daily average value of CO_2 concentration for each house.

A completely randomized block design was used to evaluate the effects of season in broiler production. The effects of season (autumn vs. spring) on thermal comfort and growth performance were analyzed with the t-test procedure in the statistical analysis software Minitab 17. Analyses of percentage data were conducted after arcsine square root transformation of the data. Differences were considered statistically significant at P≤0.05.

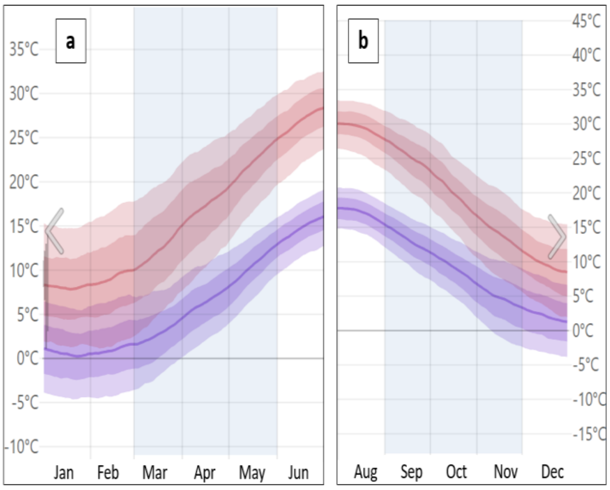

Figure 2. Outdoor temperature data at the location of broiler houses during spring and autumn seasons

Results

The temperature, RH and THI of front and back side of houses is shown in the Table 3. The findings indicate that while the temperature on the front side of the houses remained consistent across seasons, the back side exhibited a significant increase in temperature during spring compared to autumn (28.8ºC vs. 27.9ºC, P<0.001). This difference may be attributed to variations in solar exposure and ventilation dynamics, which could affect the microclimate within poultry houses (Onagbesan *et al*., 2023). The higher temperatures in spring could lead to increased metabolic rates in broilers, potentially impacting their growth performance and FCR value (Wasti *et al.,* 2020). Relative humidity levels were found to be similar between the seasonal groups on both the front and back sides of the houses (P>0.05). This stability in humidity is crucial as excessive humidity can exacerbate heat stress in broilers, leading to decreased feed intake and growth performance (Qiu *et al.,* 2023).

The THI, which is a critical indicator of heat stress, was significantly higher in the back side during spring (80.1%) compared to autumn (78.4%, P<0.01). Elevated THI levels can negatively affect broiler welfare and performance, as they indicate a higher risk of heat stress, which has been shown to impair growth rates and feed efficiency (Liu *et al*., 2020). In the study, a small increase in THI for spring was observed, but this did not cause an effect for performance parameters. Quintana-Ospina *et al*. (2023) found any significant variation by changes in THI commercial tropical conditions.

CO_2 concentrations were notably higher in the autumn (1801.1 ppm) than in the spring (1415.1 ppm, P<0.001). This finding suggests that ventilation practices may differ between seasons, potentially leading to increased accumulation of CO_2 in the autumn months. Elevated CO_2 levels can have detrimental effects on broiler health and performance, as they may lead to respiratory issues and reduced oxygen availability, ultimately affecting growth and feed conversion ratios (Varol *et al.,* 2018). Moreover, the relationship between CO_2 levels and overall air quality in broiler houses underscores the importance of effective ventilation systems to maintain optimal environmental conditions for poultry (Khan *et al.,* 2023).

The seasonal variations in temperature, humidity, THI, and CO_2 concentrations within broiler houses highlight the need for careful management of environmental conditions to optimize broiler performance. The significant differences observed in temperature and CO_2 levels between seasons suggest that poultry producers should implement strategies to enhance ventilation and mitigate heat stress, particularly during warmer months.

Future research should focus on developing adaptive management practices that can effectively address the challenges posed by seasonal changes in broiler housing environments. The effects of season on broiler performance parameters is shown on Table 4. The findings indicate that broilers raised in both autumn and spring exhibited similar final body weights at 42 days of age, with values of 2850.7 g and 2841.0 g, respectively (P=0.96). This suggests that seasonal variations in temperature and humidity may not significantly impact the overall growth potential of broilers during these periods, aligning with previous research that indicates environmental factors like seasonality can influence poultry performance but may not always lead to drastic differences in weight gain (Singh *et al*., 2018).

The current finding is consistent with previous studies reporting any significant differences for body weights of broilers reared in winter or summer period (Nembilwi *et al.,* 2002; Thirumalesh *et al.,* 2012). Although the study was conducted in different seasons, the similarity in final body weight between autumn and spring seasons could be explained by the effective environmental control in the poultry house. Nowadays, the use of environmentally controlled and full automated poultry houses in broiler production could minimize the negative effects of the season on performance. Current findings demonstrated that the management conditions, especially ventilation and cooling systems, had effective for maintaining a suitable environment during spring by providing good indoor air and litter quality. The mean value of feed and water intake were found to be similar between the seasons (P>0.05). However, the feed intake tended to decline in spring period compared to the autumn, with a difference of 352.7 g in the experiment. The decrease in feed intake observed during the spring season caused a significant improvement in FCR.

Table 3. The temperature, relative humidity, and THI of front and back side of the broiler houses

Season	Temperature (°C)		RH (%)		THI		CO_2
	Front	Back	Front	Back	Front	Back	
Spring	28.0	28.8	63.3	59.7	79.1	80.1	1415.1
Autumn	28.2	27.9	62.9	59.3	79.4	78.4	1801.1
SEM	0.07	0.08	0.27	0.28	0.17	0.18	33.4
P value	<0.07	<0.0001**	<0.215	<0.368	<0.19	<0.0001**	<0.0001**

*: P<0.05, **: P<0.01

Table 4. The effect of season on broiler performance parameters

Performance parameter	Season		SEM	P-value
	Autumn	Spring		
Final body weight (FBW) (g/bird)	2850.7	2841.0	121.8	0.96
Total feed intake (TFI) (g/bird)	5181.4	4828.7	263.6	0.44
Water intake (L/bird)	6.58	6.46	1.42	0.96
FCR (feed:gain)	1.53	1.38	0.02	0.03*

*: P<0.05, **: P<0.01

In previous studies, heat stress during spring and summer seasons could cause heat stress and subsequently harmful effects on feed intake (Liu *et al.,* 2020; Youssef *et al.,* 2021). It is thought that the variability in the effects of the season on broiler performance parameters among studies might be related to many management conditions and feeding principles, such as the season, housing conditions, flock health, and feed composition.

In contrast, the FCR was significantly better in broilers raised in spring compared to those in autumn (1.38 vs. 1.53, P=0.03). This finding highlights the importance of seasonal conditions on feed efficiency, suggesting that broilers in spring may experience more favorable metabolic conditions or feed quality that enhances their ability to convert feed into body weight effectively. Research has indicated that environmental stressors, such as heat during summer months, can negatively impact FCR by increasing maintenance energy requirements and reducing feed efficiency (Suryadi *et al*., 2021). The observed differences in FCR between seasons may also reflect variations in nutrient availability or the physiological responses of broilers to seasonal changes, which can influence their growth efficiency (Aggrey *et al.*, 2010).

Conclusion

This study evaluated the performance and environmental conditions of commercial broiler farms in Bursa, monitoring 12 broiler flocks during spring and autumn. Performance parameters such as body weight, feed and water intake, and FCR were assessed alongside environmental factors like temperature, humidity, THI and CO_2 levels. The findings indicate that while growth performance remained similar between seasons, feed conversion ratios were better in spring, likely due to more favorable conditions. The study highlights the importance of managing environmental variables like temperature, CO_2 levels, and ventilation to optimize broiler performance across seasons.

Ethical Statement

The ethical approval is not required for this study. This is a study field performed by standard free-range process. Any animal was suffered during this study.

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