



Seasonal Impact on Growth Performance, Economic Feasibility, Hematological Indices, and Blood Biochemical Composition of Broiler Chickens

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Abstract | The temperature of rearing facilities is a crucial aspect in broiler production. This study investigated the seasonal impact on performance, economic value, hematological and biochemical indices in broilers. Forty-two-day rearing trials were conducted for each season over the year in winter, spring, summer, and autumn using (1-day-old) male (Cobb-500) broilers ($n = 120$), grouped into six replicates of 20 birds each. All chicks were kept under hygienic and conventional broiler management and fed *ad libitum* with pelleted maize and a soybean-based diet. The birds raised in winter exhibited superior body weight, weight gain, and feed conversion ratio when compared with those raised in the other seasons ($P < 0.01$). Additionally, chickens raised in winter yielded the highest profit margin and incurred the lowest production cost for 1 kg live weight when compared with those raised in spring, summer, and autumn ($P < 0.01$). The hematological parameters of packed cell volume, hemoglobin concentration, and total red blood cell count, were affected significantly by the seasons and exhibited the highest values in winter and the lowest ones in summer ($P = 0.001$, $P = 0.009$, and $P = 0.032$, respectively). Additionally, the serum biochemical blood indices of glucose, total protein, calcium (Ca), and phosphorus (P) were significantly higher in winter than they were in summer ($P < 0.01$). Temperature influenced triiodothyronine levels, which were significantly higher in winter than in the other seasons ($P = 0.004$). The results of this study revealed that winter was the preferable season for raising chickens in terms of profitability is the winter season. The results also suggest that during various seasons the variable temperature affects not only performance and economic values but also affected blood parameters.

Keywords | Season, Performance, Profitability, Hemato-biochemical parameters, Broiler

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INTRODUCTION

The poultry sector is characterized by rapid growth, worldwide, and broilers are the preferred type of poultry, raised mainly for meat (Mallick et al., 2020). The broiler industry differs from other livestock production in that broilers have the shortest life cycles, low capital investment, high returns, and quick turnover (Bhende, 2006). In the

near future, the global demand for poultry meat is projected to grow exponentially. By 2050, a 33% increase in the world's population is expected (UNO, 2015), necessitating a 70% increase in food production. Chicken constitutes an inexpensive protein supply for humans; consequently, the demand for poultry meat is likely to increase to enable feeding this vast human population (Ramachandran, 2014; Osti et al., 2017).

Genetic and environmental factors can influence the growth characteristics of broilers (Okere, 2014). Choosing the most appropriate season for raising broilers is crucial for increasing productivity (Koknaroglu and Atilgan, 2007). Seasonal variations, climatic changes, and increasing extremities in weather patterns, are major nongenetic factors affecting broiler productivity and profitability (El-Faham et al., 2017). This study aimed to aid broiler farmers in choosing optimal rearing facilities for specific environmental and weather conditions and to achieve favorable broiler performance (May and Lott, 2000). When the thermo-neutral ambient temperature was increased, the feed consumption of 4–8-week-old broilers exhibited a significant decrease (Yahav et al., 1996; Singh et al., 2019). When broilers are exposed to high temperatures, their feed consumption declines and their daily nutrient intake decreases to minimize metabolic heat production and preserve homeothermy (Abu-Dieyeh, 2006). By contrast, low ambient temperatures increase feed intake, body weight gain, feeding effectiveness, and survivability as the broiler chicken adjusted easily to less temperatures than higher ones (Ali et al., 2015).

Additionally, fowls react to high temperatures with physiological changes like many other animals which minimize the negative impacts of the hot climate (Donkoh, 1989). The health status of broiler chickens can be assessed using hematological parameters. Numerous factors including conditions of microclimate and macroclimate, raising methods, season, and pathological factors affect blood values (Mohamed et al., 2012). Increased metabolic energy requirements because of low temperatures are concomitant with changes in the hematological and biochemical parameters of the blood. Broiler chickens that are subjected to low temperatures exhibit increased hematocrit value, hemoglobin (Hb) concentration, serum protein, and glucose (Yahav, 2002). Serum triiodothyronine (T3) is associated with temperature regulation in broilers and is a vital growth promoter. A circulating T3 concentration was reported to correlate positively with feed intake and negatively with temperature (Blahova et al., 2007). This study investigated the seasonal influence on growth parameters, hemato-biochemical indices, and the economic value of broilers.

MATERIALS AND METHODS

This study was consistent with the ethical standards and regulations established by the Local Laboratory Animal-Care Committee (Faculty of Veterinary Medicine, Zagazig University). The Committee on Institutional Ethics approved the experimental procedure (Approval No. ZU-IACUC/2/F/36/2021).

EXPERIMENTAL PROCEDURE

This study was conducted in four consecutive seasons (winter, spring, summer, and autumn). In each season, a total of 120 one-day-old male Cobb-500 broilers were obtained from a commercial hatchery. The broilers were grouped in six replicates of 20 birds each. Each group was allocated to a clean floor pen (2 m²; bird density: 10 chicks m⁻²) covered with a 3 cm layer of sawdust as bedding. Chicks were brooded at 32°C for the first 3 days, and then the environmental temperature has not been adjusted, depending on the outside weather during the entire period. The relative humidity was maintained between 50% and 60%. The program of lighting during the trial was 23L: 1D. The diet (starter, grower, and finisher; Table 1) was provided as pellets and designed for optimal nutritional performance (NRC, 1994). Water and feed were provided *ad libitum*. All chicks were vaccinated against Gumboro and Newcastle disease.

GROWTH PERFORMANCE

Growth parameters were assessed by registering the initial weight on day 1, the final BW on day 42, and the gain in BW was measured as the variance among FBW and initial BW. Feed was withheld for 2 h before weighing the birds. The feed intake per replicate was calculated over the trial period as the difference between provided feed and residual feed. The feed conversion ratio (FCR) was determined as the ratio of feed (g) to weight gain (g) according to (Wanger et al., 1983). The survivability was determined by dividing the number of birds sold by the number of chicks entered. The dead birds during the study were weighed, and all feed losses were collected and weighed in each pen to ensure accurate measurements of feed intake and FCR.

COLLECTION OF BLOOD SAMPLES

On the morning of day 42, we collected the blood from the wing veins of animals using a sterilized syringe (5 mL). Three specimens from each replicate were randomly selected (n = 18). An immediate blood sample was preserved in two test tubes, one of which contained an anticoagulant (EDTA) and the further one without. The tube that contained the anticoagulant enabled estimating the packed cell volume (PCV), hemoglobin concentration, and total red blood cell (TRBC) count. The other test tube was stored for approximately 3 h at room temperature and then centrifuged at 3000 rpm for 10 min for biochemical analysis. Hemolysis-free samples for serum were transferred into clean vials and preserved at -20°C to determine serum glucose, total protein (TP), T3, calcium (Ca), and phosphorus (P).

LABORATORY ANALYSIS

Examination of blood hematology comprised the following tests: TRBC count was estimated using a Neubauer

Table 1: Ingredients and chemical composition of basal diets (as-fed basis).

Ingredients	Starter (0 to 10 d)	Grower (11 to 24 d)	Finisher (25 to 42 d)
Yellow maize	56.00	60.60	63.90
Soybean meal (48%)	34.86	29.00	25.00
Maize gluten (60%)	3.50	4.50	4.00
Soybean oil	1.80	2.00	3.66
Calcium carbonate	1.00	1.00	0.90
Dicalciumphosphate	1.80	1.90	1.60
Sodium chloride	0.30	0.30	0.30
Premix*	0.30	0.30	0.30
DL- Methionine (98%)	0.18	0.14	0.11
Lysine, HCl (78%)	0.16	0.16	0.13
Toxinil	0.10	0.10	0.10
Calculated chemical composition†			
ME, MJ/kg	12.74	13.00	13.41
CP (%)	23.30	21.44	19.57
EE (%)	4.28	4.60	6.24
CF (%)	2.64	2.55	2.63
Ca (%)	0.97	0.98	0.86
Available P (%)	0.47	0.48	0.41

*Supplied per kg of diet: Vitamin A, 12 000 IU; vitamin D3, 2200 IU; vitamin E, 26 IU; vitamin K3, 6.25 mg; vitamin B1, 3.75 mg; vitamin B2,

6.6 mg; vitamin B6, 1.5 g; pantothenic acid, 18.8 mg; vitamin B12, 0.31 mg; niacin, 30 mg; folic acid, 1.25 mg; biotin, 0.6 mg; Fe, 50 mg; Mn, 60 mg; Cu, 6 mg; I, 1 mg; Co, 1 mg; Se, 0.20 mg; Zn, 50 mg; and choline chloride, 500 mg.

†Calculated according to NRC (1994) tables.

ME: Metabolisable energy, CP: Crude protein, EE: Ether extract, CF: Crude fibre, Ca: Calcium, P: Phosphorus.

hemocytometer after appropriate dilution (Campbell, 1995); the hematocrit value was measured through a method of capillary micro-hematocrit using a Janetzki centrifuge (Kelly, 1979); and Hb concentration (using Drabkin's solution diluent) was estimated using cyanmethemoglobin according to (Ritchie et al., 1994). Regarding biochemical indices, the concentration of glucose was estimated with an enzymatic method on the basis of the glucose oxidase reaction, using a kit (Spinreact, SA, Spain). An automated biochemical analyzer was used to estimate TP (g/L) using a biuret technique adapted by Gornall et al. (1949) and Kohn and Allen (1995). Colorimetric techniques were used to determine serum Ca and P. A biochemical analyzer was used to measure the serum level of total T3 IMMULITE 1 (DPC). Analysis of the proximate composition of the test ingredient was performed by AOAC (2000).

ECONOMIC FEASIBILITY OF BROILER CHICKENS

The potential profitability of the studied broiler chickens was evaluated using a partial budgeting technique provided in the following:

$$\text{Cost of feed/kg BW} = [(\text{Feed consumption per bird} \times \text{Cost of 1 kg feed}) / \text{Final weight}] \text{ (Eq. 1)}$$

$$\text{Total cost/kg BW} = [\text{Total costs per bird} / \text{Final BW per bird}] \text{ (Eq. 2)}$$

Where total costs included total feed costs, the price for the one-day-old chicks, and the costs for litter, labor, veterinaries, electricity, and miscellaneous items.

$$\text{Profit/kg BW} = \text{Price of kg live BW} - \text{Total cost per kg BW} \text{ (Eq. 3)}$$

$$\text{Profit-cost ratio} = \text{Profit per kg BW} / \text{Total cost per kg BW} \text{ (Eq. 4)}$$

STATISTICAL ANALYSIS

One-way analysis of variance was performed to analyze the data with SPSS, after normality was ensured using the Shapiro-Wilk test and variance homogeneity among experimental units was verified using Levene's test. Replicate or individual birds were used as the experimental units for all statistical analyses. The mortality percentages were converted into Arcsin values and then retransformed after analysis into the initial values. The significance among values of means was estimated using the Bonferroni test with the significance level at (P < 0.05).

GROWTH PERFORMANCE

The results revealed that seasonally changing environmental temperatures exerted the main influence on broiler performance, health conditions, and physiology. A significant seasonal effect was observed in the final weight, BW gain, FCR, and livability percent (Table 2). Feed consumption and initial BW exhibited no significant effect. Among the groups from all seasons, those raised in winter exhibited the highest FBW and body weight gain (BWG; $P = 0.005$ and 0.006 , respectively). The FCR was significantly lower ($P = 0.024$) in winter than it was in the other seasons. Additionally, livability percent was within the normal range, however, a significantly lower percent was observed in summer ($P = 0.011$), followed by winter, spring, and autumn.

ECONOMIC EVALUATION

Birds raised in winter incurred a significantly lower total cost per kg BW compared with those raised in summer, spring, and autumn (Table 3, $P = 0.005$). Additionally, they generated the highest value in terms of profit/kg BW, profit–cost ratio ($P > 0.001$), and the price of kg live BW ($P = 0.007$), in comparison with the birds of the other seasons. Regarding the feed costs, differences between seasons were insignificant ($P > 0.05$).

HEMATOLOGICAL AND BIOCHEMICAL PARAMETERS

Table 4 presents the seasonal influence on the hematological parameters. The birds raised in winter exhibited higher hematological indices PCV ($P = 0.001$), Hb ($P = 0.009$), and TRBC count ($P = 0.032$) when compared with those raised in summer, which exhibited the lowest ones. The biochemical parameters (blood glucose, TP, T3, Ca, and P) were significantly higher in winter than in summer, spring, and autumn ($P = 0.026$, $P = 0.015$, $P = 0.004$, $P = 0.001$, and $P = 0.012$, respectively; Table 5).

DISCUSSION

SEASONAL EFFECT ON GROWTH PERFORMANCE OF BROILERS

Table 2 presents the seasonal influences on the growth parameters of broilers. A significant seasonal effect was observed in final values for BW, BWG, FCR, and percent of livability, as birds raised in winter exhibited superior values for FBW, BWG, and FCR (2766.67, 2720 g/bird, and 1.64, respectively) followed by birds raised in autumn, summer, and spring. This is consistent with a previous study reporting the highest BW in winter (Osti et al., 2017). In contrasting studies (Nembilwi, 2002; Thirumalesh et al., 2012), the weight of broilers was not affected by the season. A significantly ($P < 0.05$) higher FBW observed in winter may be a consequence of high feed utilization, which

might be attributable to the more appropriate microclimate. Previous studies have reported 18°C – 23°C as an ideal temperature (Aengwanich and Simaraks, 2004; Al-Aqil et al., 2009; Yakubu et al., 2007). At this temperature, birds can control their heat balance relatively well and require low levels of energy for their activity (Syafwan et al., 2011). Hence, broilers adapt to lower temperatures more easily than to higher ones (Manning and Wyatt, 1990). The lower BW, BWG, and higher FCR during summer and spring in this study were likely because of the high temperature. This meant that the bird had to balance heat production and heat loss, for example, through panting. This behavior incurs a metabolic cost in terms of energy, resulting in a higher FCR (Abu-Dieyeh, 2006). Also, the significantly higher ($P < 0.05$) livability percent for birds raised in the autumn, spring, and winter could be due to a more appropriate temperature for broiler chickens. By contrast, the low livability percent of broiler in summer could be due to heat stress and a lowered immune response, which can cause heatstroke, increased pathogens, and finally death (Sarma et al., 2019; El-Faham et al., 2017). However, the overall livability was above 95%, which is considered normal for broiler chickens.

SEASONAL EFFECT ON THE PROFITABILITY OF BROILERS

Regarding the economic feasibility, a significantly ($P < 0.01$) lower total cost/kg BW, higher profit, and profit–cost ratio were observed in winter, which is consistent with the findings of Iqbal et al. (2012) who reported the 1 kg live broiler production cost to vary considerably among farms, seasons, and countries. The highest production cost was observed in summer and was attributable mainly to a higher FCR. The production cost per unit at high temperatures is higher than that at low temperatures because of the energy expenditure incurred by body heat dissipation processes; this lowers the production efficiency at high temperatures (McDowell, 1972). However, the highest profit in winter may be attributable to the higher market price, because the market price of live broiler was the prime factor affecting the profitability of the birds (Roy, 2000; Raha, 2007; Ali et al., 2015). These findings are consistent with Rahman et al. (2003) and Ramdur et al. (2010) they also found that higher profits for broiler production occur in winter with the highest profit–cost ratio than in other seasons and less sale value per bird in the summer season.

SEASONAL EFFECT ON THE HEMATOLOGICAL PARAMETERS OF BROILERS

Physiological reactions in broilers respond to seasonal and environmental temperature variations. Poultry belongs in the category of homeothermic birds that can live comfortably in a relatively small thermal neutral zone. In this study, significantly higher hematological values of PCV,

Table 2: Effect of seasons on production performances of broiler¹

Items ²	Seasons				SEM ³	P-value
	Winter	Spring	Summer	Autumn		
Initial BW (g/bird)	46.27	40.15	44.40	42.50	0.122	0.128
Final BW (g/bird)	2766.67 ^a	2516.28 ^b	2636.81 ^{ab}	2730.95 ^a	17.23	0.005
TFI (g/bird)	4459.17	4325.83	4410	4521.80	31.64	0.253
BWG (g/bird)	2720.40 ^a	2476.13 ^c	2592.41 ^{ab}	2688.45 ^a	14.76	0.006
FCR (feed: gain)	1.64 ^b	1.75 ^a	1.70 ^{ab}	1.68 ^{ab}	0.019	0.024
Livability (%)	96.04 ^b	97.83 ^{ab}	95.20 ^c	97.97 ^a	0.120	0.011

Means bearing different superscripts within the same row are significantly different ($P < 0.05$).

¹Results are presented as the means of 6 replicate pens with 20 birds per pen.

²BW: Body weight, TFI: Total feed intake, BWG: Body weight gain, FCR: Feed conversion ratio

³SEM: Standard error of the mean.

Table 3: Effect of seasons on cost of production and profitability of broiler¹

Items ²	Seasons				SEM ³	P-value
	Winter	Spring	Summer	Autumn		
FC (\$/kg BW)	0.65	0.71	0.70	0.71	0.009	0.253
TC (\$/kg BW)	0.89 ^c	1.12 ^a	1.05 ^b	1.02 ^b	0.023	0.005
Price of kg live BW(\$)	1.76 ^a	1.72 ^a	1.39 ^b	1.25 ^b	0.055	0.007
Profit (\$/kg BW)	0.87 ^a	0.60 ^b	0.34 ^c	0.23 ^c	0.014	<0.001
Profit-cost ratio	0.98 ^a	0.54 ^b	0.32 ^c	0.23 ^c	0.019	<0.001

Means bearing different superscripts within the same row are significantly different ($P < 0.05$).

¹Results are means of 6 replicate pens of 20 birds per pen.

²BW: Body weight, FC: Feed cost, TC: Total cost, cost of one kg feed = 0.42\$

³SEM: Standard error of the mean.

Table 4: Effect of seasons on hematological indices of broiler¹

Items ²	Seasons				SEM ³	P-value
	Winter	Spring	Summer	Autumn		
PCV (%)	37.92 ^a	31.33 ^{bc}	29.63 ^c	32.80 ^b	1.899	0.001
Hb (g/dl)	13.88 ^a	11.73 ^{bc}	11.03 ^c	12.96 ^b	0.568	0.009
TRBC (million cell/mm ³)	2.67 ^a	2.24 ^b	2.16 ^b	2.33 ^{ab}	0.009	0.032

Means bearing different superscripts within the same row are significantly different ($P < 0.05$).

¹Results are means of 3 samples from each replicate pens.

²PCV: Packed cell volume, Hb: Hemoglobin concentration, TRBCS: Total red blood cells,

³SEM: Standard error of the mean.

Table 5: Effect of seasons on some blood biochemical compositions of broilers¹

Items ²	Seasons				SEM ³	P-value
	Winter	Spring	Summer	Autumn		
Blood Glucose (mg/dl)	213.79 ^a	181.44 ^b	164.10 ^b	198.03 ^{ab}	5.1332	0.026
Total Protein (g/l)	38.60 ^a	33.79 ^{bc}	31.60 ^c	37.60 ^{ab}	2.391	0.015
T3 (ng/ml)	2.59 ^a	1.03 ^b	0.98 ^b	1.84 ^a	0.235	0.004
Ca (mmol/l)	3.17 ^a	2.39 ^b	2.29 ^b	2.56 ^b	0.502	0.001
P (mmol/l)	2.74 ^a	2.25 ^b	2.01 ^b	2.40 ^{ab}	0.019	0.012

Means bearing different superscripts within the same row are significantly different ($P < 0.05$).

¹Results are means of 3 samples from each replicate pens.

²T3: Triiodothyronine, Ca: Calcium, P: Phosphorus.

³SEM: Standard error of the mean.

Hb, and TRBC count were observed in winter (37.92%, 13.88 g/dL, and 2.67 million cell/mm³, respectively), because of an elevated energy demand due to the cold temperatures. This means that the cardiovascular system must adapt to the altered energy needs of the body. Therefore, the increase in hematocrit (PCV), hemoglobin, and blood volume was observed in broilers subjected to low ambient temperatures, which is consistent with the results of Blahova et al. (2007). Moreover, Yahav and Hurwitz (1996) reported that the decline in hematocrit value for the Cobb strain during summer could be due to a decrease in the erythrocytes count, which is caused by increased damage in erythrocyte or hemodilution. Additionally, the lower levels of Hb concentration in the summer could be due to high temperatures changing the spread of iron in the organisms of birds, which has been described by Vecerek et al. (2002) and Comito et al. (2007). The results demonstrated that the high ambient temperature in summer reduced the TRBC count. This is in harmony with the findings of Khan et al. (2002), who reported that elevated temperatures lead to a decline in TRBC count, which might be caused by diminished oxygen consumption. This, in turn, may be accompanied by a simultaneous decrease in the production of red blood cells due to a lower basal metabolic rate.

SEASONAL EFFECT ON THE BIOCHEMICAL INDICES OF BROILERS

Blood biochemical indices serve as an effective indicator of bird health and determining them allows identifying metabolic alterations (Filipović et al., 2007). In this study, serum glucose, Ca, and P concentrations were significantly decreased throughout the summer compared with those in spring, autumn, and winter seasons, with birds raised in winter exhibiting the highest values. The decrease in glucose concentration, Ca, and P during the summer might be an outcome of the decrease in feed intake. However, it could also be caused by the increased consumption of water as a response to heat stress, which leads to hemodilution and thereby a reduction in carbohydrate consumption. This finding is in the line with the previous research carried out by Abdalla and Nawal (2009). Additionally, the birds raised in winter exhibited a significant ($P < 0.05$) elevation in the concentration of TP when compared with birds raised in other seasons. This could be a result of the increase in feed consumed by the birds accompanied by a higher digestibility of protein because of the low temperatures (Mohamed et al., 2012). Temperature affects T3, a hormone that influences feed consumption and weight gain. The circulating concentration of T3 seems to be correlated positively with feed intake and negatively with temperature (Stojevic et al., 2000). In this study, significant changes in T3 concentration were observed. The serum values of T3 were higher in winter (2.59 ng/mL) than in autumn, spring, and summer. This result is consistent with

the results of Yahav (2002).

CONCLUSION

To conclude, Cobb-500 commercial broiler chickens exhibited the most favorable production and economic performance (including the highest profit at the lowest cost of producing 1 kg meat) in winter. Additionally, the highest hemato-biochemical values were also observed in winter. Thus, the preferred season for small-scale broiler farmers to earn the highest profit is winter, although they must take extra care during the chick period. Additionally, farmers may seek to control environmental variables to obtain better livability, FCR, and body weight in summer.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORS CONTRIBUTION

R.R. designed the study plan, gathered literature, and compiled the manuscript. F.A.M.H. provided technical assistance in writing and revising the manuscript. All the authors read and approved the final manuscript.

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