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RESEARCH ARTICLE
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The Effect of Halquinol (HAL) on Growth Performance, Carcass Traits and Blood-lipid Profile in Broiler Chickens

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ABSTRACT

A global trend towards removing antibiotic growth promoters (AGPs) from animals reduces intestinal diseases and contributes to the investigation of effective production-sustaining methods in the post-AGP era. Thus, halquinol (HAL) has been used to improve gut health and efficacy. The present study was carried out to evaluate the efficacy of HAL as a substitute for AGPs in broiler chickens. A total of 240 seven-days-old SPF broiler chickens were randomly assigned to four dietary groups and each with twenty birds. The groups were: T0 (control), BD + without HAL; T1, BD + HAL @0.5g/kg feed; T2, BD + HAL @0.75g/kg feed; and T3, BD + HAL @1g/kg feed. On day 35, the broiler chickens fed HAL @1g/kg feed had higher body weight, growth and feed conversion ratio ($P<0.05$) than the other groups. There was no significant variation in blood profile, however, there were statistically significant differences ($P<0.05$) in lipid profile parameters among the treatment groups. Furthermore, in a cost-benefit analysis, broiler chickens fed HAL @1g/kg feed had a significantly ($P<0.05$) higher net profit than other dietary treatment groups. Based on the findings of this study, it may be recommended to use HAL supplementation of up to 1g/kg feed as a commercial growth booster for broiler production.

Keywords: Broiler, Blood-lipid profile, Carcass characteristics, Growth performances and Halquinol (HAL).

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INTRODUCTION

Poultry exhibits considerable potential as an industry for alleviating destitution in Bangladesh. The poultry industry in Bangladesh is of significant importance in terms of employment avenue and meeting the protein demands of the human population (Islam et al., 2014; Sultana et al., 2017). Bangladesh has over 304.17 million poultry population and this sector provides 22%-27% of the country's total meat supply (Islam et al., 2023). Also, poultry meat alone contributes 37% of the total meat output in Bangladesh (Hamid et al., 2017). In recent years, there has been a considerable rise in broiler productivity and demand for broiler meat has been incrasing on a daily basis, as most people, regardless of caste or religion, like chicken (Kamruzzaman et al., 2021; Korver, 2023). This has been made possible by the use of antibiotic growth promoters (AGP) in poultry husbandry as preventative measure against or for the treatment of bacterial infections (Abreu et al., 2023). Sub-therapeutic antibiotic concentrations are incorporated into the broiler diets in several countries, except Europe, in an effort to maintain intestinal health and growth (Abudabos et al., 2016; Proctor and Phillips, 2019). The widespread use of these antimicrobials leads to the development of resistance, which has serious implications for the health of animals and potentially, humans (Mehdi et al., 2018; Boovaragamoorthy et al., 2019; Ma et al., 2020). A recent study predicts an 8.0% increase in food-producing animal antibiotic use by 2030 (Mulchandaniid et al., 2023). Many nations, including the EU, have banned AGP on food-producing animals (Tang et al., 2019). In this setting, finding environmentally sustainable poultry rearing options is crucial. AGP alternatives with similar antibacterial and growth-promoting characteristics in broiler birds are now the topic of intensive academic research (Yang et al., 2015; Wolfenden et al., 2007; Rashid et al., 2020).

Halquinol (HAL), a powerful non-antibiotic antimicrobial agent, is widely used in the poultry industry as a primary growth promotor with antimicrobial, antifungal, and antiprotozoal effects (Maira et al., 2016; Habib et al., 2019). Because of its broad spectrum of activity and ability to regulate peristalsis in the intestines, HAL is useful in addressing malabsorption disorders (Kandepu et al., 2012; Nischal et al., 2012). HAL possesses a mechanism that slows peristalsis in the gut, which aids nutrient absorption (Kandepu et al., 2012). It has been used as a feed supplement in poultry as well as a swine growth promoter in Brazil, Peru, Thailand, Colombia, Indonesia, India and Bangladesh (Maira et al., 2016; Costa et al., 2017; Basit et al., 2020; Mendoza-Ordoñez et al., 2023). Although there have been no microbiological investigations indicating the emergence of HAL resistance, there are worries about its possible effects on the colonization barrier (WHO and FAO, 2021). Furthermore, there has been no investigation in Bangladesh on the effectiveness of HAL as an alternative to antibiotics and/or growth-promoting medicines to increase broiler chicken production. Therefore, the present study was aimed to assess the effects of HAL on broiler productivity, carcass characteristics, blood-lipid profile, and economic analysis of broiler production.

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MATERIALS & METHODS

Ethical Approval

The Institutional Committee of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur-5200, approved the experimental protocol vide Approval code: HSTU/VAS/ASN/EA/010.

Study Area and Period

The experiment was conducted from January to June 2023 in the poultry shed at the Faculty of Veterinary and Animal Science, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. The necessary laboratory facilities were also received from Physiology laboratory, Faculty of Veterinary and Animal Science, HSTU, Dinajpur with proper validation.

Facilities

The experimental birds were raised in an open-sided housing split into 12 compartments of uniform dimensions using wire mesh and bamboo materials. A 40 square foot (8ft×5ft) area was set aside to provide feeding, watering, and lodging for a total of 20 birds. Initially, the experimental house was thoroughly cleaned using tap water. After a complete washing and disinfection with bleaching powder, the ceiling, walls, and floor were all swept away, and the room was left empty for two weeks. Later, the house was disinfected with TH4$^+$ solution (Sogeval, France). At the same time, all feeders, waterers, and other necessary equipment were properly cleaned, rinsed, and disinfected with TH4$^+$ solution. Litter was made up of two to three inches of both fresh and dry rice husk. After 5 weeks, the entire litter was removed and replaced with a fresh batch of litter, while retaining the same depth as before. The litter was agitated once daily for four weeks until the trial period ended. A floor space of 2 square feet was allotted for each bird to ensure their comfort. Within each 24-hour cycle, the birds were subjected to a photoperiod consisting of 23 hours of continuous lighting followed by a 1-hour period of darkness. All of the agricultural facility's windows were left open to maintain the correct temperature and humidity levels within the enclosure. Each pen was equipped with a circular tube feeder and drinker. The feeders and drinkers were placed in such a way that broilers had easy access to food and water. The feeders were cleaned every day, and the waterers were cleaned twice a day, once in the morning and once in the afternoon.

Birds and Experimental Design

A total of 240 specific pathogen free (SPF) 7-day old broiler chicks were purchased from a commercial breeder (Kazi Farms Limited, Panchagarh, Bangladesh) and randomly divided into 4 dietary treatment groups (T0, T1, T2 and T3) with three replications of 20 birds (Table 1). The birds were segregated into distinct bamboo-constructed cage floors after being weighed. On day 4 and 21, all birds were immunized against Infectious Bursal Diseases (IBD) and on day 10 and 16 against Newcastle Disease (ND) (Table 2). Until the end of the experiment, weekly data of their performance, including live weight, feed consumption and mortality were recorded. On day 35, three birds were selected and euthanized in each replication. Then blood samples were collected for the analysis hematological parameter and lipid profile including hemoglobin (Hb), total erythrocyte count (TEC), total leucocyte count (TLC), erythrocyte sedimentation rate (ESR), packed cell volume (PCV), total cholesterol, triglyceride, high-density lipoprotein (HDL) and low-density lipoprotein (LDL). All the biochemical analysis was done using an automatic analyzer (Humalyzer 300, Merck®, Germany) following manufacturer's instructions. Then, all of the birds were sacrificed, and the organs and body parts were weighed to determine the carcass characteristics.

Experimental Diets

For this trial, HAL (Gutcare®) was purchased from a commercial company (Century Agro Limited Bangladesh) and the basal feed was procured from a commercial feed company (Nourish Poultry and Hatchery Ltd, Bangladesh). The composition of basal diet is shown in Table 3. The provision of feed occurred in three distinct phases, namely the starter, grower and finisher diet. Subsequently, the HAL (Gutcare®) powder was included into the basal diet to formulate the feed. The feed ingredients were measured using a digital weighing scale. The trial period encompassed three distinct phases, namely broiler-starter, broiler grower, and broiler finisher.

Table 1: Treatment with Halquinol (HAL) in the four experimental group of bird

Dietary Treatments		Number of birds in each replication			Total
		R_1	R_2	R_3	
Control/basal diet (Without HAL)	T_0	20	20	20	60
Basal diet + HAL (Gutcare®) 0.5g/kg feed	T_1	20	20	20	60
Basal diet + HAL (Gutcare®) 0.75g/kg feed	T_2	20	20	20	60
Basal diet + HAL (Gutcare®) 1g/kg feed	T_3	20	20	20	60
	Total number of birds				240

Table 2: Vaccination schedule

Diseases	Age of bird	Name of vaccines	Time	Route
Newcastle Disease	4th day	BCRDV	Evening	Eye drop
Infectious Bursal Disease	10th day	Gumborovac	Evening	Drinking water
Infectious Bursal Disease	16th day	Gumborovac	Evening	Drinking water
Newcastle Disease	21st day	ND Lasota	Evening	Drinking water

Table 3: Nutrients Composition of Basal diet (Paul et al., 2020)

Composition[1]	Starter	Grower	Finisher
Moisture % (Max)	12	12	12
Crude protein % (Min)	20	19	18
Fiber % (Max)	5	5	5
Calcium % (Min)	0.95	0.95	0.9
Phosphorus % (Max)	0.45	0.45	0.42
Methionine (Min)	0.45	0.45	0.42
Lysine (Min)	1.05	1.05	1
Metabolizable energy (kcal/kg) (Min)	3000	3050	3100

Max=Maximum, Min=Minimum, [1] Cobb-500 broilers were fed commercial diets primarily composed of corn and soybean meal in order to fulfill their nutritional needs.

Statistical Analysis

The data were analyzed using SPSS version 20 software, employing a one-way ANOVA in accordance with the principles of a Complete Randomized Design (CRD). The values were presented as Mean±SEM and statistical significance was assessed at a significance level of (P<0.05). A Duncan test was used to compare means between the treatment groups.

RESULTS

Productive Performances of Broiler

Body Weight Gain

Table 4 showed how HAL affects the body weight gain of broiler chickens. At the end of the experiment, birds in group T3, fed HAL @1g/kg feed, had a significantly (P<0.05) higher body weight (2368.7±20.13g/bird) compared to birds in groups T2 (2334.3±6.03g/bird), T1 (2314.0±12.16g/bird) and T0 (2237.3±6.43g/bird). Importantly, the initial body weight of each group was comparable. Bird's live weight did not differ significantly (P<0.05) between treatment groups in the first week. Nevertheless, there were substantial differences (P<0.05) in live weight across the experimental groups in the second, third, fourth, and fifth weeks. Significant differences in body weight gain (P<0.05) were found across groups. In the 1st and 3rd weeks, the birds in the three experimental groups showed no significant changes (P>0.05). T3 group showed the highest body weight (2324.3±20.21g/bird) compared to T2 (2289.7±6.51 g/bird), T1 (2269.7±11.85g/bird) and T0 (2192.7±6.66g/bird).

Feed Intake

Table 5 showed treatment group-specific feed intake for broilers of different ages. The amount of food consumed by broilers on different diets during the 1st, 3rd, 4th and 5th weeks of the experiment showed a similar pattern, with small changes that were not statistically significant (P>0.05). There was a significant difference (P<0.05) in feed consumption of broiler among dietary treatments during the trial, particularly in the second week of age and overall. HAL-fed birds in group T3 had the highest feed intake (376.0±2.64g/bird) and the control group (T0) had the lowest feed intake (363.3±3.05g/bird). Compared to the control group T0 (3236.7±6.66g/bird) and the other groups T1 (3251.0±2.64g/bird), T3 (3244.0±4.58g/bird), and group T2 (3255.3±8.50g/bird), birds with HAL supplementation showed the highest cumulative feed intake throughout the trial.

Feed Efficiency

The feed efficacy of the broiler was determined by dividing the feed intake in grams by the weight gain in grams, as illustrated in Fig. 1. There were no significant differences (P>0.05) in the feed efficiency of broilers in the first, second, third, and fourth weeks of the trial, regardless of the dietary treatments. However, there was a significant variation in feed efficiency (P<0.05) was observed at the 5-week period. Further, the statistical analysis showed a significant difference (P<0.05) in the overall feed efficiency among the different treatment groups. The birds in group T3, fed HAL@1 g/kg feed, showed the highest efficiency in converting feed to meat, with a rate of 1.39±0.01. The birds in group T2, fed HAL@0.75 g/kg feed, exhibited a conversion efficiency of 1.42±0.00. The birds in group T1, fed HAL@0.5 g/kg feed, had a reduced conversion efficiency of 1.43±0.01. Lastly, the control group T0, without HAL supplementation, had the lowest conversion efficiency of 1.48 ±0.00.

Carcass Characteristics

Table 6 showed the carcass characteristics of broilers among the different treatment groups. There were no statistically significant differences (P>0.05) in the liver and heart weights of the broiler birds. In contrast, significant differences (P<0.05) were observed across the experimental group in terms of live weight, carcass weight, breast flesh weight, thigh weight, drumstick weight, abdominal fat weight, and wing weight. Group T3 had the highest live weight, with a measurement of 2456.6±58.59 g whereas, the control group, T0, had the lowest live weight, with a measurement of 2223.3±30.55 g. In comparison to HAL-treated groups, T3

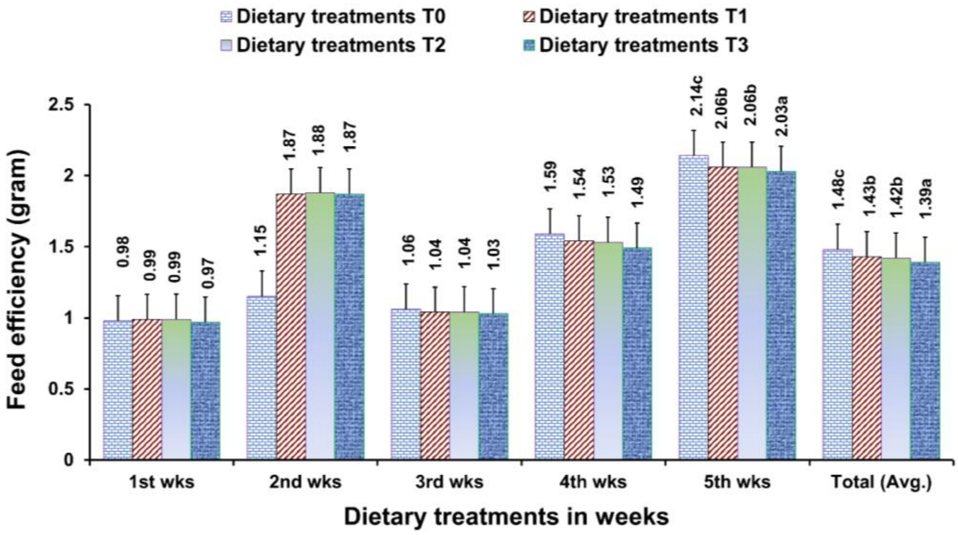

Fig. 1: The impact of incorporating Halquinol (Gutcare®) into the diet of broiler on feed efficiency. T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. The mean values with different superscript (a to c) within the treatment groups differs significantly, at least (P<0.05). All values indicate mean± Standard error of mean.

Table 4: The impact of incorporating Halquinol (Gutcare®) into the diet of broilers on their live weight gain

Body weight (g/bird/wks)	Dietary treatments				Level of significance
	T_0	T_1	T_2	T_3	
Initial Live Weight	44.7±0.58	44.3±0.58	44.7±0.58	44.3±0.58	NS
1st wks	200.3±0.58	200.3±0.58	200.7±0.58	201.3±0.58	NS
2nd wks	516.7±15.27^a	539.0 ±5.57^b	550.7±4.5^{bc}	560.0±2.00^c	*
3rd wks	1111.0±12.77^a	1146.7±15.27^b	1162.3±4.04^{bc}	1180.0±5.00^c	*
4th wks	1700.7±10.07^a	1754.3±10.50^b	1772.7±6.11^b	1803.3±15.27^c	*
5th wks	2237.3±6.43^a	2314.0±12.16^b	2334.3±6.03^b	2368.7±20.13^c	*

Legends: T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. The mean values with different superscript (a to c) within the same row differs significantly, at least (P<0.05). All values indicate mean ± Standard error of mean, NS=Non-significant, * statistically significant (P<0.05).

group (1719.0±96.81 g) had the highest carcass weight than T1 (1589.3±11.01 g), and T2 (1596.0±15.09 g) groups. Regarding the breast meat weight, HAL fed birds showed a significantly higher (P<0.05) weight than the control group. In comparison to HAL-treated groups, T3 group (605.0±21.79 g) had the highest breast weight than T1 (560.0±5.00 g) and T2 (582.7±21.94 g) groups. Similarly, regarding the thigh meat, drumstick and wing weights, HAL fed birds showed a significantly higher (P<0.05) weight than the control group. In comparison to HAL-treated groups, T3 group had the highest thigh weight (345.0±5.00 g), drumstick weight (220.0±5.00 g) and wing weight (121.0±3.60 g) than T1 (331.0±3.60 g, 207.7±2.52 g, 113.0±1.00 g), and T2 (335.3±5.03 g, 212.0±3.00 g, 114.0±1.00 g) groups, respectively.

Blood Profile

The effects of HAL on the blood parameters of experimental broiler were shown in Fig. 2. There was no significant difference (P>0.05) in the Hb levels among the treatment groups (T0-T3). Similarly, no significant differences (P>0.05) were found in the PCV, TEC, TLC and ECR value among the treatment groups.

Lipid Profile

The effects of HAL on the lipid profile of experimental broiler were shown in Fig. 3. The findings showed that there were significant differences (P<0.05) in total cholesterol, triglycerides, HDL, and LDL level among the treatment groups. Treatment group T3 had the lowest total cholesterol level (103.33±1.45 mg/dL), whereas control group T0 had the highest amount (155.67±0.88 mg/dL). On the other hand, control group T0 had the highest concentration of Triglyceride (81.33±2.40 mg/dL) whereas, the treatment group T3 had the lowest amount (50.00±1.15 mg/dL). HDL levels were highest in treatment group T3 (47±0.58 mg/dl) and lowest in the control group (36.67±0.88 mg/dL). In contrast, treatment group T3 had the lowest LDL level (55.67±1.20 mg/dL) and the control group T0 had highest LDL level (105.33±1.45 mg/dL).

Cost Effectiveness of Production

Table 7 showed the cost-effectiveness of broiler production using HAL. The results revealed that the overall production cost per bird for the treatment and control groups differed significantly (P<0.05). The costs in the T0, T1, T2, and T3 groups were USD 2.51±0.41, USD 2.53±0.16, USD 2.54±0.53, and USD 2.54±0.28, respectively. The overall profit per broiler bird differed significantly (P<0.05) between experimental and the control groups. The profit in the T0, T1, T2 and T3 groups were USD 0.81±0.72, USD 0.90±2.07, USD 0.92±0.80 and USD 0.96±2.95, respectively. In summary, the net profit per kilogram of live weight of broilers varied significantly (P<0.05) between treatment and control groups, with values of USD 0.25±0.19, USD 0.27±0.65, USD 0.28±0.26, and USD 0.30±0.86 for groups T0, T1, T2, and T3, respectively.

Table 5: The impact of incorporating Halquinol (Gutcare®) into the diet of Broiler on Feed intake

Feed intake (g/bird/wks)	Dietary treatments				Level of significance
	T_0	T_1	T_2	T_3	
1st wks	153.0±3.00	154.7±2.52	154.7±4.16	151.7±1.53	NS
2nd wks	363.3±3.05	370.0±2.00	374.0±4.36	376.0±2.64	NS
3rd wks	632.3±2.52	635.0±2.00	636.3±1.53	637.0±2.00	NS
4th wks	936.7±2.08	936.3±3.51	933.3±3.05	930.0±2.00	NS
5th wks	1151.3±4.16	1155.0±2.64	1157.0±3.00	1149.3±3.05	NS
Total (Avg.)	3236.7±6.66	3251.0±2.64	3255.3±8.50	3244.0±4.58	NS

Legends: T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. All values indicate mean±Standard error of mean, NS=Non-significant.

Table 6: Carcass characteristics of broiler fed diet with Halquinol (Gutcare®)

Carcass yield (g)	Dietary treatments				Level of significance
	T_0	T_1	T_2	T_3	
Carcass Weight	1532.7±49.8^a	1589.3±11.0^a	1596.0±15.09^a	1719.0±96.81^b	*
Breast Meat Weight	526.7±7.64^a	560.0±5.00^b	582.7±21.94^{bc}	605.0±21.79^c	*
Thigh Muscle Weight	315.0±5.00^a	331.0±3.60^b	335.3±5.03^b	345.0±5.00^c	*
Drumstick weight	198.3±7.64^a	207.7±2.52^{ab}	212.0±3.00^{bc}	220.0±5.00^c	*
Abdominal fat	30.0±2.00^a	35.3±1.53^b	38.0±2.00^b	42.7±2.52^c	*
Liver weight	58.0±2.00	61.7±1.53	60.7±3.05	63.0±2.64	NS
Heart weight	11.0±1.00	12.0±1.00	11.3±1.15	12.3±0.58	NS
Wing weight	111.7±1.53^a	113.0±1.00^a	114.0±1.00^a	121.0±3.60^b	*

Legends: T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. The mean values with different superscript (a to c) within the same row differs significantly, at least (P<0.05). All values indicate mean ± Standard error of mean, NS=Non-significant, * statistically significant (P<0.05).

Table 7: Cost effective analysis of broiler feed Halquinol (Gutcare®)

Description	To	T_1	T_2	T_3	Level of significance
Cost/chick (USD)	0.37	0.37	0.37	0.37	NS
Total feed consumed kg/birds	3.236±6.66^a	3.251±2.64^b	3.255±8.50^b	3.244±4.58^{ab}	*
Feed price/kg (USD)	0.57	0.57	0.57	0.57	NS
Cost of Halquinol (Gutcare®) (USD /bird)	0	0.02	0.03	0.03	NS
Total Feed cost (USD /bird)	1.86±0.41^a	1.87±0.16^b	1.87±0.53^b	1.86±0.28^{ab}	*
Miscellaneous (USD /bird)	0.28	0.28	0.28	0.28	NS
Total cost/bird (USD)	2.51±0.41^a	2.53±0.16^b	2.54±0.53^c	2.54±0.28^c	*
Average live wt (kg/bird)	2.237±6.43^a	2.314±12.16^b	2.334±6.03^b	2.368±20.13^c	*
Sale price/Kg live wt (USD)	1.48	1.48	1.48	1.48	NS
Average Sale price/bird (USD)	3.31±1.03^a	3.43±1.95^b	3.46±0.96^b	3.51±3.22^c	*
Net profit/bird (USD)	0.81±0.72^a	0.90±2.07^b	0.92±0.80^b	0.96±2.95^c	*
Net profit/Kg live wt (USD)	0.25±0.19^a	0.27±0.65^b	0.28±0.26^b	0.30±0.86^c	*

Legends: T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. The mean values with different superscript (a to c) within the same row differs significantly, at least (P<0.05). All values indicate mean±standard error of mean, NS=Non-significant, * statistically significant (P<0.05).

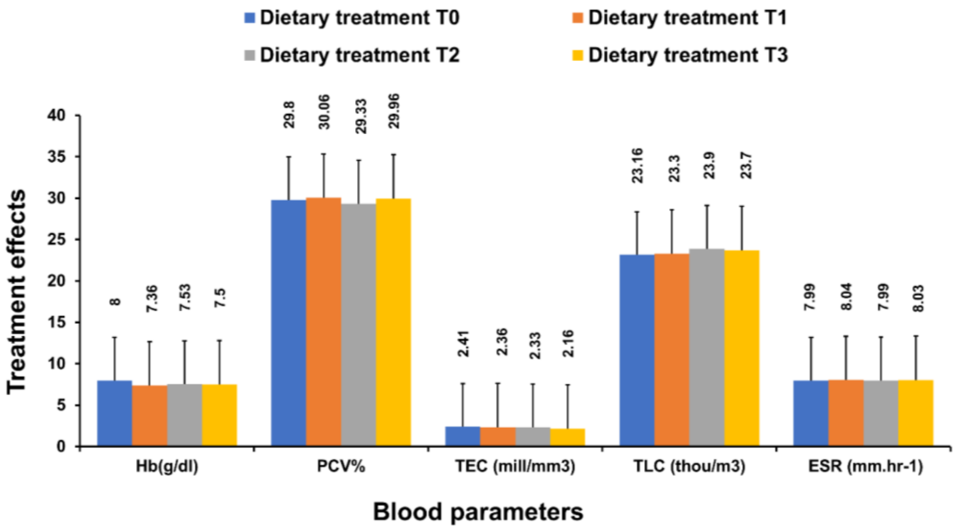

Fig. 2: Effect of Halquinol (Gutcare®) on blood parameters of broiler. T_0=Control, T_1=Halquinol@0.5g/kg feed, T_2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. All values indicate mean±standard error of mean.

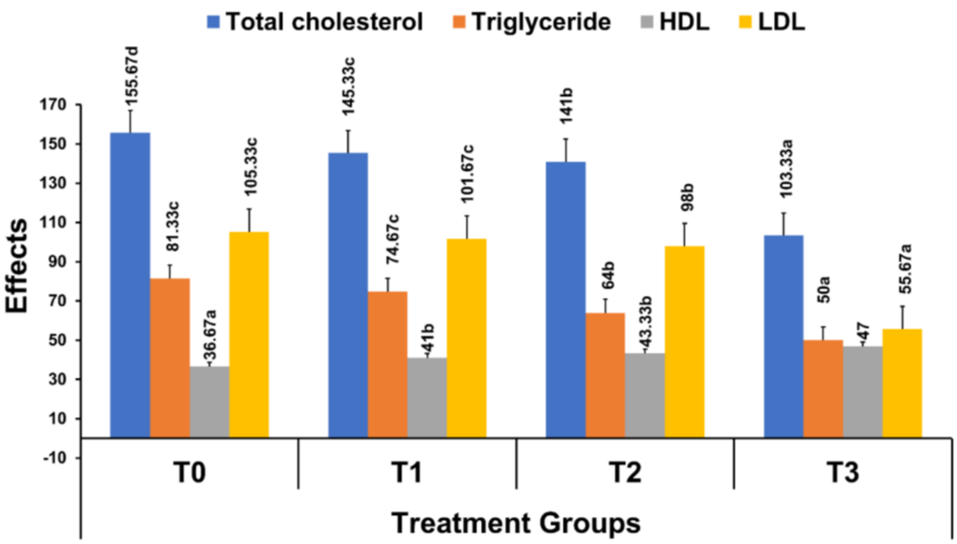

Fig. 3: Effect of Halquinol (Gutcare®) on lipid profile of broiler. T_0= Control, T1=Halquinol@0.5g/kg feed, T2=Halquinol@0.75g/kg feed, T_3=Halquinol@1g/kg feed. The mean values with different superscript (a to d) within the treatment groups differs significantly, at least (P<0.05). All values indicate mean ± standard error of mean.

DISCUSSION

According to this study, halquinol (HAL) significantly affects broiler body weight and weight gain. Birds fed 1g/kg HAL had the best results in group T3. The findings are consistent with the findings of Basit et al. (2020), who found that supplementing a basal diet with 0.03 g/kg HAL increased body weight gain. Furthermore, broilers exposed to different dietary interventions varied significantly (P<0.05) throughout the experiments. Notably, the birds in the T2 group fed 0.75g/kg HAL had the highest feed intake. In contrast, the FCR was significantly lower (P<0.05) in HAL treatment group compared to the control group. In our previous study (Habib et al., 2019) it was found that feeding 1g/kg HAL improved growth metrics, feed intake, and decreases FCR of Sonali chicken. Further, the birds in the T3 group fed 1g/kg HAL had the highest efficiency of feed conversion into flesh compared to other treatment groups. These results are correlated with the findings of Mendoza-Ordoñez et al. (2023) and Fomentini et al. (2016) who reported that adding HAL to traditional foods and combination with other antimicrobials lowered FCR and increased body weight gain. The observed outcome could be attributed to HAL's broad-spectrum antibacterial action against a range of bacteria, fungi, protozoa and mycoplasma organisms (Cosgrove and Baines, 1978). According to Kompiang et al. (1997), Halquinol addition in cassapro diets containing 20% and 30% had a significant impact on poultry performance, such as increased body weight gain and improved FCR, whereas without Halquinol supplementation reduced body weight gain and increased FCR. Mushigeri et al. (2008) conducted a study on fresh water fish showed that fishes treated with 0.1% HAL were a higher weight gain compared to untreated control group.

The current study found no significant difference (P>0.05) in the weight of both the liver and heart of the experimental birds. However, significant differences (P>0.5) were observed in the weights of carcass, breast, thigh, drumstick and wings between the experimental groups. This can be attributed to the anti-peristaltic activity of HAL, which enhances nutrient assimilation and directly contributes to the weight gain of the broiler chickens. There were no significant differences in hematological parameters (Hb, PCV, TEC, TLC and ESR) determined to be within the normal range across the various groups of birds. This suggests that supplementation of HAL has no negative effects on the blood profile of broiler chickens with physically fit and healthy throughout the experimental period. Based on the findings of this study, the addition of HAL as a supplement may be regarded safe for broiler chickens. However, this finding was not in accordance with Swetha et al. (2009) who observed that the administration of HAL to rats via oral gavage at a high dose of 1000 mg/kg body weight resulted in a substantial drop in Hb, TEC and mean corpuscular hemoglobin concentration (MCHC) and a significant rise in mean corpuscular volume (MCV).

Our study found significant variations (P<0.05) in lipid profile values (mg/dL) of total cholesterol, triglyceride, HDL, and LDL) between the different treatment groups. The T3 group had the lowest cholesterol and triglycerides (in milligrams per liter), HDL (mg/dL) and LDL mg/dL) whereas the group T0 had the highest. Due to its antioxidant characteristics, HAL may reduce oxidative stress in broiler chicks. Through oxidative stress reduction, HAL indirectly promotes lipid profile regulation. Oxidative stress harms lipid metabolism, making this important.

The experiment concluded by calculating the overall production cost per bird for each group. The control group (T0) had a total production cost of 25.1±0.41 USD. The birds supplied with HAL @0.5g/kg feed (T1) had a total production cost of 2.53±0.16 USD. Similarly, the birds supplied with HAL @0.75g/kg feed (T2) had a total production cost of 2.54±0.53 USD. On the other hand, the birds supplied with HAL @1g/kg feed (T3) had a total production cost of 2.54±0.28 USD. The maximum total profit per bird of broiler was found in group T3 (0.96±2.95 USD), followed by group T2 (0.92±0.80 USD), T1 (0.90±2.07 USD), and the lowest overall profit was observed in the control group T0 (0.81±0.72 USD). The birds in group T3, fed HAL @1g/kg feed, exhibited the highest net profit per kilogram of live weight (0.30±0.86 USD). Group T2 birds fed HAL @0.75g/kg feed, with a net profit of 0.28±0.26 USD. In group T1, birds fed HAL @0.5g/kg feed showed a net profit of 0.27±0.65 USD. The control group T0 had the lowest net profit per kilogram of live weight at 0.25±0.19 USD. Thus, HAL as a feed supplement yields a significant cost benefit over the control group (T0).

Conclusion

The study findings suggest that HAL acts as a growth promoter with that significantly influences the weight gain and nutritional efficiency of broiler chickens. Consequently, the HAL supplementation into feed at concentrations of up to 1g/kg can be used to improve broiler growth, thereby circumventing the necessity for antibiotic treatment. Commercial broiler farmer could more profit by using growth-promoting agents that are both successful and cost-effective, thus contributing to the economic development of Bangladesh. The utilization of these commodities yields economic benefits and does not pose any adverse impacts on human health.

Conflicts of Interest

The author declare that they have no conflict of interest.

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Authors' Contributions

MAH and AH conceived, designed the experiments, project administration, funding acquisition, analyzed the data and wrote the original draft; MAH performed the experiment, sample collections, prepared Figures/Tables and draft preparation; AH, US, MAH and MNA supervision, designed the experiments, reviewed and edited the draft, MGR was responsible for data analysis. All authors reviewed and approved the manuscript.

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