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EFFECTS OF TAMARIND PULP ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, HEMATOLOGICAL AND SERUM INDICES OF BROILER CHICKENS UNDER HEAT STRESS.

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ABSTRACT:

The study investigated the effects of varying levels of tamarind pulp extract in drinking water on growth performance, carcass characteristics, serum, and hematological profile of broiler chickens. The experiment followed a completely randomized design, and data were analyzed using analysis of variance (ANOVA). A total of 150 day-old Abor-Acre broiler chicks were allocated to five dietary treatments, each replicated three times with 10 chicks per replicate. The control group (T1) received water without tamarind pulp extract, while T2, T3, T4, and T5 received 25, 50, 75, and 100 g of tamarind pulp extract per liter of water, respectively. The average daily feed intake (ADFI) did not differ significantly across the treatment groups; however, final weight, total weight gain (TWG), and average daily weight gain (ADWG) were significantly influenced by the treatment. The dietary inclusion of tamarind pulp extract had no significant effect ($P > 0.05$) on carcass parts, including the breast, neck, back, thigh, drumstick, thigh, shank and or visceral organs measurements such as intestinal length and empty gizzard weights. Serum albumin and total protein levels for T2, T3, T4 and T5 were significantly lower than the control. Hemoglobin, white blood cell counts and mean corpuscular hemoglobin (MCH) levels were significantly higher in birds receiving T2 compared to the control and other treatments groups. Mean corpuscular hemoglobin concentration (MCHC) levels were significantly higher in T4 and T5 than in T2, T3, and control groups. Adding tamarind pulp extract did not affect feed intake or carcass characteristics. In conclusion, the inclusion of tamarind pulp extract in drinking water of broiler chicken did not affect feed intake or carcass characteristics but influenced certain growth performance parameters and hematological indices.

INTRODUCTION:

Broiler production plays a critical role in meeting global meat demands; however, heat stress remains a significant challenge to its sustainability. 'West African temperatures are predicted to rise by +0.5°C every decade over the twenty-first century, faster than the world average of +0.3°C per decade' (Todzo *et al.*, 2020). Heat stress in broilers is a physiological mismatch between heat energy generated from tissue and heat energy transfer from the birds to the environment (Renaudeau *et al.*, 2012). As homeotherms, broilers require environmental temperatures that are between 18 and 24 degrees Celsius (Cahaner *et al.*, 2008). This temperature range appears to be difficult to achieve all year round, particularly in the tropics, making broilers susceptible to heat stress (Chand *et al.*, 2014; Yosi *et al.*, 2016). Modern commercial broiler breeds have been reported to have higher metabolic activity and generate more heat, making them more vulnerable to heat stress (Onagbesan *et al.*, 2023). According to a recent study by Wang*et al.* (2020), heat stress was found to negatively affect broilers' resistance and these features steadily decreased as the ambient temperature increased. When poultry are exposed to heat stress, they exhibit a variety of physiological abnormalities, such as hormone irregularities, respiratory problems, electrolyte imbalances, and immune system abnormalities (Teeter *et al.*, 1985; Sohail *et al.*, 2010; Lara and Rostagno, 2013; Goo *et al.*, 2019). The consequences of these physiological abnormalities are reduction in feed intake, nutrient utilization, growth rate, egg production, egg quality, and feed efficiency, which eventually lead to economic losses in poultry (Sahin *et al.*, 2009). Feed intake decreases by 5% for every degree rise in temperature above 32 °C (Balogun *et al.*, 2013).

According to Syafwan *et al.* (2011), there are a number of feeding techniques that may help poultry reduce heat load. These include feeding wet diets to concurrently promote water intake, choosing feed ingredients that are high in protein or energy, supplying feeds with varying particle sizes or structures that will slow the digestion process, and restricting feeding during hot periods to minimize heat load. Suganya *et al.* (2015) also reported some nutritional measures aimed at mitigating the adverse effects of heat stress on poultry and; one of such measures is the use of vitamin C (ascorbic acid). Monogastric animals and poultry synthesize vitamin C for healthy development and growth (Ghazi *et al.*, 2012), but typically not enough to meet their biological needs during heat stress. For heat-stressed chicken, vitamin C supplementation at 250 mg/kg feed has been reported to enhance productive performance, nutritional digestibility, immunological responses, and antioxidant capacity (Khan *et al* 2012, Gouda *et al.*, 2020). Several herbs and plant products, such as turmeric, hot red pepper, ginger, thyme, sweet wormwood, rosemary, moringa, licorice, cinnamon, ginkgo reduce the negative effects of heat stress in poultry (Abld El-Hack *et al*., 2020). Tamarind (*Tamarindus indica*) is a tropical fruit rich in vitamin C and other phytochemicals, with concentrations ranging from 4.79 to 201.7 mg/100 g (Fabiana, 2012; Okello *et al*., 2018). Despite its potential, limited research has been conducted on the use of tamarind pulp to enhance broiler productivity under heat stress conditions. Thus the objective is to assess the effects of various doses of aqueous tamarind pulp extract in drinking water on the growth performance, carcass traits, hematology, and serum biochemical profile of broilers under heat stress.

MATERIAL AND METHODS

Experimental location

The study was conducted at the Poultry Research Farm of the Department of Animal Science, Federal University Gashua, in May 2023. The experimental site is located within the campus situated at latitude 12° 52' 2.9" N and longitude 11° 57' E, in the semi-arid zone of north-eastern Nigeria. This area has a hot and dry climate, typical of the Sahel region. The annual rainfall ranges from 500 to 1000 mm, while temperatures range between 38 and 40 °C during March to June, with relative humidity varying from 13.06% to 71.09%. The site is at an elevation of 299 meters above sea level (Wikipedia, 2011).

Pre-experimental activities

Pens were carefully cleaned and disinfected before the experiment started, and each treatment and replication were identified and labeled. Feed and water troughs were cleaned, and a foot bath was placed at the entrance of the pen to prevent the spread of diseases and maintain good bio-security.

Source and preparation of test materials:

Twenty five kilograms (25kg) of Shell-free *Tamarindus indica* fruits were purchased at a local market in Gashua, Bade local government, Yobe State. Shade-dried for five days and kept in a cool, dry place. Thereafter, it was soaked in concentrations of 25, 50, 75, and 100 g/liter of water for 12 hours. The seeds were then removed by hand, and the solution was sieved with cheesecloth to obtain the tamarind pulp solution, which was used for the purpose of this study.

Experimental birds and their management:

A total of one hundred and fifty (150) unsexed day-old Abor Acre broiler chicks were procured from a reputable hatchery in Jos Plateau State. Chicks were randomly allotted to five dietary treatment groups of thirty birds and replicated three times with ten birds per replicate in a completely randomized design. The birds were reared under heat stress conditions with ambient temperatures between 30.9 and 40.85 °C during the trial period. Routine vaccination and daily routine management practices were carried out as required. Feed and water were offered *adlibitum* throughout the 8 weeks of the trial period.

Experimental diets

During the trial, all five treatment groups had unrestricted access to water and commercial broiler starter and finisher feeds containing 22% and 19% protein and 3000 and 3100 kcal/kg metabolizable energy respectively. Tamarind pulp was administered in the drinking water at rates of 0 g/L for T1, 25 g/L for T2, 50 g/L for T3, 75 g/L for T4, and 100 g/L for T5.

Data collection

The parameters measured during this experiment included feed intake, body weight, weight gain, feed conversion ratio, carcass and organ weights, mean ambient temperature, daily water intake as well as hematological and serum indices. Daily Feed intake was determined by allotting a known quantity of feed to the birds and subsequently weighing the residual feed at the end of each day.The daily feed consumed was calculated as the difference between the feed offered and the remaining feed, and the mean weekly feed intake per bird per day was computed by summing the daily feed intake over seven days and dividing by seven. Bird body weight was recorded for each pen at the start of the experiment (placement) and subsequently at weekly intervals. Weekly body weight gain was calculated as current week's body weight and the previous week's body weight. Feed conversion ratio was determined for each treatment by dividing the total feed intake (in grams) by the corresponding body weight gain. At the end of the experimental period, three birds per replicate were randomly selected for carcass analysis. The selected birds were fasted overnight to ensure an empty gastrointestinal tract, weighed and humanely slaughtered via severing of the jugular veins. Blood was allowed to drain completely from the carcasses. The carcasses were scalded in water maintained at 80°C for three minutes to facilitate feather removal, which was then manually performed. The viscera were extracted by making an incision through the vent, and the dressed carcasses including the neck, wings, thighs, drumsticks, and breasts were subsequently weighed. Additionally, the weights of internal organs including the heart, liver, gall bladder, spleen, and gizzard were measured. All measurements were recorded using a precision digital scale accurate to 0.01 g. Daily water consumption was determined by subtracting the unused water from the total allotted water for each day. The mean ambient temperature was calculated by averaging temperature readings taken at 7:00 a.m., 1:00 p.m., and 5:00 p.m. daily. For the hematological and serum indices, at the conclusion of the feeding trials, three birds from each replicate group were also randomly selected and subjected to overnight fasting with ad libitum access to water. The birds were handled carefully to minimize stress, and blood samples (5 mL per bird) were collected aseptically from the brachial vein using 2.5 mL syringes fitted with 23-gauge needles. The collected samples were promptly capped, labeled, and stored appropriately. Blood samples designated for hematological evaluation were collected into tubes containing ethylene diamine tetraacetic acid (EDTA) as an anticoagulant, while those intended for serum biochemical analysis were collected in anticoagulant-free containers.

Statistical analyses

Obtained data were subjected to statistical analysis using One Way Analysis of Variance, SPSS version 26, 2019 (SPSS Inc., Chicago, IL, USA). The means were compared using Duncan Multiple Range Test. Differences were considered statistically significant if ($P \leq 0.05$).

RESULTS AND DISCUSSION

Growth performance.

The average daily feed intake (ADFI) values recorded in this study were101.78, 101.78, 105.85, 105.28, and 106.25 g for treatmentsT1, T2, T3, T4, and T5 respectively (Table 1). These values did not differ significantly ($P>0.05$) across the birds treatments. This finding is contrary to the assertion made by Saleh *et al.* (2012) that feed intake decreases with increasing levels of tamarind pulp extract. Similarly, the assertion made by Chowdhury *et al*. (2005) that dietary tamarind influenced the feed intake of layers contrast with the findings of this study. These discrepancies may be attributed to the difference in physiological response of layers and broilers to tamarind pulp extract and probably the method of administration as tamarind was incorporated into the diet in their studies. The relatively low feed intake values observed compared to standard 160 g/bird/day, may be attributed to the elevated ambient temperatures during the trial period (31.58 to 40.85ºC), which exceeded the thermal comfort zone for broilers. Body weight, feed intake, and feed conversion ratio were significantly reduced in broilers subjected to heat stress (ZiadHamdanMahmod Abu-Dieyeh, 2006). Studies have shown that feed consumption decreases by 5% for each degree Celsius as the temperature rises between 32 and 38 °C. The feed conversion ratio for the dietary treatment groups did not differ significantly ($P > 0.05$) among the treatment groups. This observation did not align with the findings of Chowdhury *et al.* (2005), Saleh *et al. (*2012), and Shaolin *et al.* (2020), who reported tamarind pulp and tamarind leaves fed to laying hens and broilers increased feed efficiency. The findings of this study revealed significant differences ($P < 0.05$) among the treatment groups in terms of final weight, total weight gain (TWG), and average daily weight gain (ADWG). Notably, the birds in dietary treatments 3 and 4 exhibited TWG and ADWG values that were statistically comparable to those of the control group. The finding of this study do not align with earlier reports by Aengwanich *et al.* (2009), Saleh *et al.* (2012), and Shinde *et al.* (2015), which demonstrated that tamarind pulp extract enhance broiler weight gain. Similarly, the results differ from the findings of Banjo et al. (2018), who reported no significant difference in body weight gain when T1 (0 g/L), T2 (36 g/L), and T3 (72 g/L) were added to the drinking water of broilers. The low weight gain observed in this study may be attributed to reduced feed intake and suboptimal feed utilization. Heat stress has been reported to induce low-grade mucosal inflammation, which consequently lowers blood flow across the birds' gastrointestinal tract (Holtmann *et al.*, 2018). The growth rate in broilers decreases when there is elevation in environmental temperature as this leads to reduction in feed consumption causing an eventual insufficient vital nutrient intake. Additionally, heat stress diminishes feed digestibility within the gastrointestinal tract. These factors collectively impair digestion and nutrient absorption, ultimately reducing total weight gain (TWG) and average daily weight gain (ADWG) in heat-stressed chickens.There were no significant differences ($P<0.05$) in the mean water intake between the treatments, as indicated by Table 1. This is in line with the findings of Saleh *et al*. (2012), who reported no significant difference ($p<0.05$) in mean water intake among groups provided with a solution of tamarind pulp in their drinking water. The water intake values in this study are statistically similar, Water and feed consumption rates are interdependent, so reduced water intake can also lead to reduced feed intake (Daniels, 2010).

Table:1 Growth performance indices of broiler chickens fed varying levels of Tamarind pulp in drinking water

Parameters	T1 (0g/L)	T2(25g/L)	T3(50g/L)	T4(75g/L)	T5(100g/L)	SEM
IW(g)	40	41	40	41	40	0.24
FW(g)	1950^{a}	1875^{b}	1950^{a}	1950^{a}	1875^{b}	18.37
TWG(g)	1910^{a}	1834^{b}	1910^{a}	1909^{a}	1835^{b}	18.41
ADFI(g/day)	101.78	101.78	105.85	105.28	106.25	1.077
ADWG(g/day)	34.10^{a}	32.75^{b}	34.10^{a}	34.08^{a}	32.76^{b}	0.490
FCR	2.98	2.98	3.10	3.08	3.24	0.040
TWI (Liters)	211.89	213.82	214.15	214.05	214.20	0.245

a, b, Means with different superscripts in a row differ significantly ($P<0.05$), SEM= Standard Error of Mean, IW=initial weight, FW=Final weight TWG=Total weight gain, ADFI=Average daily feed intake, ADWG=Average daily weight gain, FCR=feed conversion ratio, TWI= Total water intake.

Table 2. Average weekly ambient temperatures((°C)

WEEKS	7:00 am	1:00 pm	5:00 pm	SD
4	32.44	40.85	38.24	1.5
5	31.58	40.64	37.61	1.90
6	30.97	39.74	35.94	1.49
7	31.58	40.25	37.31	1.49

SD= Standard Deviation.

The average weekly ambient temperature range of 30.97 to 40.85 ^{o}C recorded during the feeding trial is presented in Table 2. This range of value is higher than 18 - 22 ^{o}C for the comfort and optimum performance of broilers, which explains the reason for the lower feed intake that was recorded. The findings of this study are consistent with those of Syafwan *et al*. (2012), who found that high temperatures reduced feed intake, protein intake, energy intake, and body weight gain in broilers. Similarly, ZiadHamdan Mahmod Abu-Dieyeh (2006) observed that broiler chickens exposed to heat and provided with feed exhibited significantly lower body weight gains compared the control group. The effects of dietary treatment on the carcass characteristics of broilers are summarized in Table 3. The results show no significant differences ($P < 0.05$) in the weights of the breast, neck, back, thigh, drum stick, thigh, shank, wing, among the treatment groups. These findings align with those of Balaji *et al.* (2013), who reported no significant variation in the organ weights among treatment groups in an experimental trial involving the feeding of decorticated tamarind seed meal to broilers. Additionally, the dressed weights and dressing percentage are statistically similar across all treatment groups in this study. This is consistent with the findings of Saleh *et al* (2012) who in a similar study reported no significant difference in dressed weight and dressing percentage of broilers fed tamarind pulp.The intestinal length was statistically comparable across the treatment groups in this study, which align with observation of Mutaz *et al* (2020) in a similar trial involving broilers fed raw and boiled tamarind seeds. Visceral organ parameters such as empty gizzard showed no significant differences ($P<0.05$) which is also in agreement with an earlier report by Mutaz *et al* (2020) who reported no significant variation in gizzard weight. However, serum levels of albumin, total protein, globulin, triglycerides, uric acid, creatinine, aspartate amino transferase, alanine amino transferase, alkaline phosphatase, sodium, potassium, chloride, and calcium measured were significantly ($P<0.05$) influenced by the administration of aqueous tamarind pulp solutions (Table 4). The albumin and total protein levels observed for T2, T3, and T4 were significantly lower than the control group, which could probably be due to reduced nutrient supply. These findings are inconsistent with the findings of Joseph *et al.* (2021), who observed no significant difference in albumin, total protein, and globulin in a similar trial on Noiler. The variation in the result may be attributed differences inbird's strains. The serum triglyceride levels in T3, T4, and T5 were significantly lower than those in the control group; however, birds on dietary treatment two (T2) had similar values to the control group. This result is consistent with Shaolin *et al* (2020) findings, who observed reduced triglyceride values in a similar trial with dietary tamarind leaves on broilers.Serum electrolytes such as sodium recorded for T1, T3, T4, and T5 fall within the normal range of 135 to 145 mEq/L reported by Jain (1993) for chickens, however, the potassium levels were all higher than 3.5 to 5.0 mEq/Lnormal range for chickens. Significant differences ($P<0.05$) were observed in this study's hematological values, this is consistent with the findings of Saleh *et al*. (2013) who observed a significant ($P\leq0.05$) increase in RBC and at variance with the findings of Jana *et al.*, (2015) who observed significant ($P\leq0.05$) decline in Hb, RBC, PCV, and WBC in chicks fed on Tamarind seed supplemented diet. Joseph et *al (*2021) reported no significant difference in hematological values in a similar trial on Noiler strain of birds. Values obtained for hemoglobin, white blood cells, and mean corpuscular hemoglobin for birds on the experimental diet two were significantly higher than the control and other treatment diets. The hemoglobin range values of (11.93 to 14.00g/dl) fall within the normal range values (11.60 to 13.68 g/dl) reported by Campbell (2013); however, the white blood cell values were lower than the normal range value (4.07 to 4.32) reported by Campbell (2013). The RBC range value of 2.29 to 2.56 is within the normal range value of 2.5 to 3.5 reported by Jain (1993).The MCHC range values of 38.50 to 52.33 recorded were higher than the normal reference range value of (32.41 to 33.37) reported by Campbell (2013). This implies the birds' anemic condition, which could probably be due to low feed intake.

Table 3: Carcass characteristics and organ weight of broiler chickens fed varying amount of Tamarind pulp in drinking water.

Parameters	T1(0g/L)	T2(25g/L)	T3(50g/L)	T4(75g/L)	T5(100g/L)	SEM
Live weight (g)	1950^{a}	1875^{b}	1950^{a}	1950^{a}	1875^{b}	18.37
Dressed weight(g)	1390	1325	1385	1389	1310	17.45
Dressing percentage	71.28	70.66	71.02	69.00	69.86	0.41
Neck(g)	34.00	32.70	42.30	46.40	41.37	7.64
Breast(g)	250.17	210.40	232.37	195.37	156.37	28.72
Back(g)	111.03	151.00	147.33	135.53	111.03	15.57
Thigh(g)	66.00	55.47	59.63	59.67	56.37	7.94
Drum stick (g)	116.33	119.73	118.03	111.00	102.20	3.12
Wings(g)	95.93	99.93	107.6	110.10	85.93	16.47
Head (g)	41.33	34.17	37.67	37.30	30.47	3.26
Shank(g)	100.00	85.07	92.37	88.60	76.65	11.61
Full gizzard (g)	30.40^{b}	43.43^{a}	40.00^{a}	38.37^{a}	38.50^{a}	3.22
Empty gizzard (g)	25.80	30.13	27.97	26.47	27.72	2.95
Liver (g)	23.97	24.67	24.07	23.95	24.20	3.58
Heart (g)	5.03	4.87	5.27	4.23	4.47	0.99
Kidney (g)	1.20	1.27	1.80	0.93	1.83	1.39
Spleen(g)	1.55	1.50	1.70	1.69	0.33	0.44
Pro-ventriculus (g)	5.33	5.77	5.57	4.53	5.82	0.89
Intestine length(cm)	169.67	178.33	164.33	173.33	180.67	6.28
Intestine weight (g)	90.00^{a}	89.53^{a}	97.03^{bc}	133.67^{b}	191.03^{bc}	18.29

a, b, c… Means with different superscripts in a row differ significantly ($P<0.05$), SEM= Standard Error of Mean

Table 4: Serum profile of broiler chickens fed varying levels of tamarind pulp extract.

Parameters	T1 (0g/L)	T2(25g/L)	T3(50g/L)	T4 (75g/L)	T5(100g/L)	SEM
Albumin (g/l)	15.23^{a}	14.57^{b}	14.37^{b}	13.83^{c}	13.80^{c}	0.14
Total protein (g/l)	27.67^{a}	26.47^{b}	26.15^{b}	25.24^{c}	25.07^{c}	0.26
Globulin (g/l)	12.43^{a}	11.89^{ab}	11.73^{ab}	11.73^{ab}	11.27^{b}	0.13
Triglyceride.(mmoL/L)	1.02^{a}	1.02^{a}	0.59^{c}	0.64^{c}	0.81^{b}	0.04
Uric(mmoL/L)	1.93^{a}	1.87^{a}	1.63^{b}	1.83^{a}	1.93^{a}	0.03
Creatinine(mmoL/L)	43.33^{b}	42.01^{b}	39.67^{c}	43.00^{b}	45.67^{a}	0.57
AST(U/L)	109.34^{c}	111.00^{bc}	117.00^{a}	113.33^{b}	110.32^{c}	0.80
ALT (U/L)	7.67^{d}	12.67^{b}	11.67^{c}	15.04^{a}	6.33^{e}	0.86
ALP ((U/L)	57.33^{b}	50.00^{c}	66.33^{a}	64.69^{a}	46.69^{d}	0.11
Na (mmoL/L)	142.67^{bc}	147.00^{a}	145.68^{ab}	141.08^{c}	143.90^{bc}	0.67
K (mmoL/L)	6.03^{a}	5.58^{b}	5.47^{b}	5.56^{b}	6.16^{a}	0.07
Cl (mmoL/L)	106.32^{b}	110.32^{a}	108.67^{ab}	102.67^{c}	106.00^{b}	0.77
Ca (mmoL/L)	2.75	2.65	2.68	2.56	2.56	0.07

a, b, c… Means with different superscripts in a row differ significantly (P0<05), SEM= Standard Error of Mean. AST=Aspartate aminotransferase, ALT=Alanine transaminase, ALP=alkaline phosphatase, Na=Sodium, K= Potassium, Cl=chloride, Ca=calcium

Table 5: Hematological profile of broiler chickens fed varying amount of tamarind pulpextract in drinking water

Parameters	T1 (0g/L)	T2(25g/L)	T3(50g/L)	T4 (75g/L)	T5(100g/L)	SEM
Lymphocytes	85.83^{a}	76.27^{d}	79.30^{c}	58.20^{e}	82.73^{b}	2.59
Granulocyte	3.72^{e}	8.73^{b}	9.07^{a}	8.22^{c}	7.073^{d}	0.52
Platelet	96.00^{a}	49.67^{c}	59.33^{b}	48.67^{d}	34.33^{e}	5.55
Hb (g/dl)	13.00^{b}	14.05^{a}	11.93^{c}	13.82^{ab}	12.84^{bc}	0.23
RBC ($10^{12/}$/L)	2.45^{a}	2.49^{a}	2.29^{b}	2.55^{a}	2.493^{a}	0.02
WBC (10^{9}/)	98.19^{d}	118.08^{a}	93.74^{e}	107.85^{b}	98.73^{c}	2.32
MCH (pg)	52.67^{c}	56.96^{a}	52.21^{c}	54.03^{b}	51.93^{c}	0.50
MCHC (g/dl)	51.56^{b}	38.81^{d}	48.73^{c}	51.67^{b}	52.33^{a}	1.35
MCV (fl)	102.17^{c}	100.27^{d}	107.33^{a}	105.37^{b}	99.23^{e}	0.82

a, b, c, d, e Means with different superscripts in a row differ significantly (P0<05), SEM= Standard Error of Mean. HB=hemoglobin, RBC= Red blood cell, WBC=White blood cell, MCH= Mean corpuscular hemoglobin, MCHC Mean corpuscular hemoglobin concentration MCV= Mean corpuscular volume.

CONCLUSION AND RECOMMENDATION

Tamarind pulp extract significantly influenced the final weight, total weight gain, mean daily weight gain, and the weights of the full gizzard and intestines in broilers. However, it did not affect mean daily feed consumption (ADFI), cutup parts or and other visceral organs. Notably albumin and total protein levels were significantly lower in T2, T3, and T4 compared to control, suggesting potential implications for long-term health and production efficiency. To optimize its use, further research is needed to determine the ideal inclusion levels and assess its long-term effects on broiler health and production performance.

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