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Research Article
The Impact of Feeding Strategies to Reduce the Heat Stress in Broiler Production

Agnès Osei-Adjei, Armstrong Donkoh, Goodman Kantanka Sarfo and Jacob Alhassani Hamidu

Department of Animal Science, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract

Objective: This study aimed to evaluate feeding strategies to increase broiler growth rate, reduce heat stress and improve welfare. **Materials and Methods:** A total of 240 Cobb 500 day-old chicks were distributed in a completely randomized design in a factorial arrangement (3×2) forming 3 treatments: T1 (control-*ad libitum* feeding), T2 (feed withdrawn between 11 am to 4 pm daily) and T3 (*ad libitum* feed +1% palm oil) and (2 levels of water treatments: P1 (plain portable water) and P2 (*Tetrapluera tetraptera* powder dissolved in water, as organic anti-heat stressor). Data on growth rate, carcass analysis and blood biochemical parameters were collected. Data were analyzed using the generalized linear model (GLM) procedure of SAS. The level of statistical significance was set at $p<0.05$. **Results:** The results showed that the total feed consumption, final body weight and weight gain were higher in T3 than that of T1. Both the major and full breast muscle weights for T3 was higher than those of T1 and T2. The carcass parameters were not affected by feeding strategy, water treatment, or their interactions, except for head and full gizzard weights. Platelet counts for T3 was higher but mean platelet volume (MVP) and platelet large cell ratio (PLCR) was higher for T1 than that of T3. The MVP was also higher for P1 than that of P2. **Conclusion:** The results showed that feeding strategies influenced broiler growth more than water treatment. Prekese had phytochemicals that have inhibitory effects on respiratory illnesses and coccidiosis, such as saponins, flavonoids, polyphenols and tannins.

Key words: *Ad libitum* feeding, broiler growth rate, feed plus oil, feed withdrawal, hematology, *Tetrapluera* tetraptera

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Corresponding Author: Jacob Alhassan Hamidu, Department of Animal Science, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Poultry production has been severely hampered by climate change, effects of heat stress and poor feeding strategies which negatively affect the sustainability of production[1,2]. Several studies on feeding strategies and management of heat stress especially in the tropics have been carried out in broilers[3-5]. Research has shown that, within 16-26°C, which is called the thermoneutral zone, poultry can maintain a constant body temperature with the least effort[6]. Under high ambient temperatures, poultry birds try to regulate their body temperature by modifying their behavior and physiological homeostasis in order to decrease the temperature of their body. Some nutritional manipulations and combinations have been shown to reduce stress in broilers[3,7].

Fasting during warmer time of the day minimizes heat burden and increases survival chances of broilers[8]. Birds become heat-stressed when their body temperature becomes higher than the optimal range for basic daily activities. All classes and ages of birds exhibit similar behavioral characteristics when exposed to heat. However, meat-type birds are more susceptible to heat stress[6]. The effects are also more prominent in older birds as they have a larger body size, higher metabolism and less surface area for dissipating excess heat than young birds. Heat stress decreases feed intake, weight gain and meat quality in broilers[3,9].

During the growing phase, high temperatures deteriorate broiler's meat quality characteristics. In order to minimize heat increment, feeding time should be reduced or birds should be fed during cool hours of the day[9]. Studies have shown that heat stress has negative effects on the production performance and meat characteristics of broiler[8]. A decline in feed consumption during high temperature results in poor broiler performance, which reduces growth rate and meat quality as well as feed utilization efficiency[4,6,9]. Therefore, broiler feeding strategies should be developed to minimize the impact of heat stress on growth and welfare.

Globally, climate change has impacted poultry and livestock production[1]. The purpose of this research was to explore the best strategies for reducing heat stress, increasing animal welfare, meat yield and quality through feeding during hot weather conditions in broiler production.

MATERIALS AND METHODS

Location and period of study: The study was conducted at the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana located at a latitude of 06°41'N and a longitude of 01°33'W with an altitude of 261.4MSL, above sea level[10,11]. All experiments were conducted according to the Procedure for Animal Research Ethics Committee (AREC) of the Kwame Nkrumah University of Science and Technology, Kumasi-Ghana, Q and Planning Unit[12].

Experimental animals: A total of 240 day-old Cobb 500 broiler chicks were obtained from Topman Farms, Ntinsere in the Atwima Nwabiagya North District, Ashanti Region. On arrival, birds were weighed and randomly assigned to one of the research pens labelled according to feeding and water treatments. The initial weight of birds were ranged from 43.77-47.50 g. Brooding pens were installed with 100 watts of infrared fluorescent brooding bulbs to provide heat. Bedding materials, consisting of wood shavings, were spread to about 2 mm in thickness. Drinkers and feeders were also provided in the pens for the chicks according to recommended spacing and water was provided *ad libitum*. Birds were vaccinated against Newcastle disease virus and Gumboro and medicated according to a recommended schedule approved by the Veterinary Service Directorate of Ghana's Ministry of Food and Agriculture.

Experimental design: A total of 240 day-old Cobb 500 broiler chicks were randomly distributed in completely randomized design in a 3×2 factorial arrangement with 3 levels of feeding strategies and 2 levels of water treatments and 2 replications with 20 birds in each replicate. The treatments were: T1 (control-*ad libitum* feeding), T2 (feed withdrawn between 11 am to 4 pm and T3 (*ad libitum* feed +1% palm oil). Two levels of water treatment were: Plain water (P1) and Aidan Fruit (prekese) water (P2) as anti-stress, water was given unrestricted. On the second day, experimental feed and water were administered. From the first week, leftovers were weighed and recorded. Weekly body weight and body weight gain (BWG) were recorded and calculated by deducting the initial body weight of the previous week from the final body weight of the current week. The birds were transferred from the brooder pens to the grower pens after three weeks of brooding while maintaining their respective treatment groups.

Experimental diets: Standard broiler starter feed (Galdus pre-starter mash) with crude protein of 22.00% and metabolizable energy of 3150 kcal kg^{-1}) was purchased to feed birds for the first three weeks[13]. Palm oil (1%) was added to the feed to constitute treatment 3 (T3) to feed the birds from week four to week seven. Locally available feed ingredients were compounded to formulate the broiler

Table 1: Composition of formulated broiler finisher diet

Ingredients	Quantity (%)
Maize	60
Fish	13
Soybean	15
Wheat bran	8
Oyster shell	2
Vitamin premix	0.5
Salt	0.5
Dicalcium	0.5
Lysine	0.5
Total	100

Table 2: Nutrient composition of the control diet and feed with 1% palm oil at finisher stage of broiler production

Nutrient	Control feed	Control feed with 1% palm oil added
Crude protein	21.11	20.95
Crude fiber	2.61	2.55
Fat	3.52	4.48
Calcium	1.66	1.66
Phosphorus	0.84	0.83
Sodium	0.37	0.37
Methionine (M)	0.38	0.38
Lysine	1.58	1.57
Cystine (C)	0.03	0.03
M-C	0.41	0.41
Metabolizable energy (kcal kg^{-1})	2833.00	2906.00

M-C: Methionine (M)+Cystine (C)

finisher feed that meets the broiler requirements according to NRC[14] (Table 1). Nutrient compositions of both starter and finisher diets were calculated and proximate analysis of the diets was performed according to the AOAC[15] (Table 2 and 3), respectively.

Growth performance: The following parameters were measured on weekly basis: Body weight, body weight gain, feed intake and water intake. Mortality was recorded daily and the feed conversion ratio was calculated as the feed intake divided by the body weight gain. At 7 weeks of age, two birds from each replicate were selected and euthanized by cervical dislocation and scalded in boiling water for carcass analysis.

Slaughtering of birds and carcass analysis: Two birds from each replicate were selected and their live weights were recorded and then slaughtered. The bled weight of the birds was also recorded after bleeding for about 5-10 min after slaughtering. They were then wet-plucked and eviscerated. Internal organs (liver, heart, intestine and gizzard) were excised and separately weighed to determine the dressing weight and the dressing percentage. The weights of the shank, head and neck were also recorded. Pelvic and abdominal cavity fats and those around the gizzard were removed and weighed. The breast muscles were split into minor and major breast muscles and weighed separately and then put together and weighed.

Hematological analysis and biochemistry: Blood samples were collected from the neck region of 2 birds into separate labeled centrifuge tubes containing an anticoagulant (EDTA). The blood samples were analyzed for total platelets, hemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), mean corpuscular volume (MCV) hematocrit (HCT) and mean corpuscular hemoglobin concentration (MCHC) using a Hematological Auto Analyser (Cell-DYN 1800). Total cholesterol (TCHOL), Triglycerides (TG), high-density lipoprotein (HDL), Low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) in blood were analyzed according to the procedure of chemistry using an analyzing kit which was supplied by med source Ozone Biomedicals Pvt Ltd, using enzymatic (cholesterol Esterase, cholesterol Oxidase and Peroxidase) method at the CAN LAB, KNUST. A 1000 and 10 µL of cholesterol reagent and serum were pipetted into a test tube and labeled as Total cholesterol (Tc) respectively. Another 1000 µL of cholesterol reagent was again pipetted into a test tube and labeled as Blank (B). Samples were then mixed thoroughly and incubated for 5 min at 37°C. The absorbance of total cholesterol was read against the Blank using a calorimeter. Results were expressed as mg dL^{-1}. Triglycerides in blood were also analyzed by using the enzymatic (lipoprotein lipase, Glycerol kinase, Glycerol-3-Phosphate oxidase, Peroxidase, 4-Aminoantipyrine and ATP) colorimetric method. 1000ul and 10ul of Triglycerides reagent and serum were pipetted into a test tube respectively and labeled as (T). Another Triglycerides reagent was pipetted and labeled as Blank (B). Samples were mixed thoroughly and incubated for 10 min at 37°C. The absorbance of test (T) was then read against the Blank with a calorimeter. HDL (high-density lipoprotein)-cholesterol was estimated using 300 and 200 µL of precipitating reagent and serum respectively and was also pipetted into a centrifuge tube and mixed well. It was then centrifuged to stand at 25°C for 5 min and centrifuged again at 300 rpm for 10 min to obtain a clear supernatant. A 1000 and 100 µL of cholesterol reagent and the supernatant obtained respectively were mixed in a test tube and labeled as Test (T), another 1000 and 100 uL of cholesterol reagent and distilled water were mixed in a test tube labeled as Blank (B). Both test tubes were incubated at 37°C for 5 min. The absorbance of the test (T) was read against the Blank with a calorimeter. LDL (Low-density lipoprotein) in blood was determined using the following equation:

LDL (Low-density lipoprotein) = Total cholesterol-HDL (High-density lipoprotein)-Triglycerides

Table 3: Proximate analysis of experimental diet for Broiler starter and finisher

Parameters on as fed (%)	Control starter diet (%)	Starter diet with 1% palm oil (%)	Control finisher diet (%)	Finisher diet with 1% palm oil (%)
Moisture content	11.0	10.70	10.5	10.90
Ash content	5.8	5.70	12.0	13.58
Crude protein	22.0	23.10	21.8	24.00
Crude fat	4.5	8.30	5.3	10.20
Crude fibre	3.5	3.85	4.2	4.45
Nitrogen free extract	50.5	45.60	43.7	34.00
Metabolizable energy (kcal kg^{-1})	3044.0	3341.00	2987.0	3087.00

Statistical analysis: Data were analyzed using two-way ANOVA with the help of Generalized Linear Model procedure of SAS[16]. Where a significant treatment effects were exists, differences between treatment means were compared by Duncan Multiple Range Test. Differences of $p<0.05$ were considered statistically significant. The statistical model included the fixed effect of 3 feed treatments, the fixed effect of 2 water treatments and the interaction of feed and water treatments as shown in equation 1:

$$Y_{ijk} = \mu+\alpha_i+\beta_j+\alpha\beta_{ij}+\epsilon_{ijk} \quad (1)$$

where, Y_{ijk} is the response to treatment, μ is the overall mean from the treatment, α_i is the fixed effect due to feeding treatment, β_j is the fixed effect due to water treatment, $\alpha\beta_{ij}$ is the interaction between the two treatments and ε_{ijk} is the residual error terms.

RESULTS AND DISCUSSION

Nutrient composition of *Tetrapleura tetraptera* (fruits): The phytochemical composition of the different parts of the *Tetrapleura tetraptera* was reported by Akin-Idowu *et al.*[17] and is presented in Table 4. The composition shows different antinutritive and nutritive characteristics of the plant. These phytochemical characteristics identified in the above plant are known to have biological and beneficial effects including growth promotion, increased carcass characteristics and meat quality of animals through the enhancement of physiological, digestion and nutrient absorption capacities[18]. Additionally, the proximate analysis (Table 5) showed that crude fiber (CF), ash and ether extract (EE) values were higher than the range of 17-20.24% CF, 9% ash and 4.98-20.36% EE as reported by Okwu[19]. The CP value was lower but within the range (7.44-17.56%) as reported by Okwu[19]. The NFE value obtained (74.24%) was high. The variation in the nutrient composition could be attributed to the different geographical conditions, edaphic factors and processing methods used. However, the quantitative and qualitative composition of the phytochemicals found in the fruit was not determined in this study.

Growth performance of broilers

Feed treatment: The initial chick weights were not different between the feeding treatments (Table 6). Among feeding treatments, there was a significant difference in total feed intake ($p = 0.0374$), final body weight ($p = 0.0365$) and average weight gain ($p = 0.0378$) of the birds during the 7 week period. Birds in T2 and T1 had the same final body weight and the same was true for birds in T2 and T3. The significantly higher growth performance of birds in T3 group confirm the results of a study conducted by Hake *et al.*[20] who found that palm oil has a positive effect on the live weight of broilers. Also, the palm oil was reported to improve the growth performance of birds by increasing feed intake and absorption and decreasing heat increment of the supplemented diet, resulting in an enhanced utilization of the metabolizable energy[21].

In addition, Das *et al.*[22] reported that the inclusion of palm oil in the diet of broilers improved its palatability and reduced its dustiness thereby increased the feed intake. According to Das *et al.*[23], up to a 4% inclusion level of palm oil in broiler diets improved the weight gain as well as feed conversion ratio. The present findings are comparable to a previous study conducted by Zhang *et al.*[9] who observed that average daily feed intake, final body weight and average daily body weight gain of feed restricted birds at 63-day of age remained the same as the *ad libitum* fed birds. In a related study, however, Mahmood *et al.*[24] reported that birds kept off feed for 10 hrs gained significantly more weight and utilized their feed more efficiently than those of *ad libitum* fed birds. The water intake, FCR and mortality were not different between the feeding treatments. Birds in T3 had higher water intake and a better FCR.

Table 4: Phytochemical composition (mg/100 g) of the dry fruit of *Tetrapleura tetraptera* (Prekese)[17]

Fruit sections	Total polyphenols	Flavonoids	Saponins	Tannin	Phytate
Seeds	38.05±0.21	10.30±0.42	60.80±11.88	675.50±152.03	3,545.00±77.78
Pulp	1,866.88±1.02	410.75±1.06	953.40±9.33	1,097.50±26.16	5,170.00±42.43
Woody shell	2,907.15±2.19	354.60±0.85	641.50±18.81	135.50±20.51	1,021.00±15.56

Table 5: Nutritional composition of the dried fruit of *Tetrapleura tetraptera* (as fed)

Parameters (%)	On as fed basis (%)
Moisture content	2.03
Crude protein	8.55
Crude fat	4.28
Crude fibre	5.95
Ash content	4.95
Nitrogen free extract	74.24
Metabolizable energy	3265 kcal kg^{-1}

Table 6: Effects of feeding strategy and water treatments on the overall growth performance of broiler chickens

Source	Initial chick weight (g $bird^{-1}$)	Total feed intake (g $bird^{-1}$)	Total water intake (L $bird^{-1}$)	Final body weight (g $bird^{-1}$)	Average weight gained (g $bird^{-1}$)	FCR	Mortality (%)
Feeding strategy							
Ad-libitum (T1)	44.740	4248.930^{b}	12.330	2309.530^{b}	2127.070^{b}	1.920	12.500
Feed withdrawal (T2)	45.040	4422.460^{ab}	12.650	2363.640^{ab}	2181.470^{ab}	1.880	16.670
Ad-libitum+oil (T3)	46.560	4687.170^{a}	13.260	2625.765^{a}	2445.010^{a}	1.810	10.420
SEM[1]	0.550	90.340	0.490	68.790	69.780	0.050	4.280
p-value[2]	0.115	0.037	0.449	0.037	0.038	0.445	0.602
Water							
Plain water (P1)	44.760	4420.860	12.550	2387.830	2201.730	1.910	10.520
Prekese water (P2)	46.140	4484.850	12.940	2478.120	2300.630	1.830	15.870
SEM	0.448	73.765	0.403	56.166	56.978	0.044	3.496
p-value	0.072	0.562	0.530	0.299	0.266	0.216	0.320
Interaction							
T1*P1	43.770	4292.680	11.870	2232.69	2049.27	1.980	10.710
T1*P2	45.700	4205.190	12.800	2386.37	2204.87	1.850	14.290
T2*P1	44.880	4465.270	12.460	2279.29	2090.62	1.930	16.670
T2*P2	45.210	4379.650	12.830	2447.980	2272.32	1.83	16.67
T3*P1	45.630	4504.630	13.330	2651.520	2465.31	1.83	4.17
T3*P2	47.500	4869.720	13.190	2600.000	2424.71	1.80	16.67
SEM	0.780	127.760	0.700	97.280	98.69	0.08	6.06
P-value	0.542	0.206	0.755	0.492	0.509	0.780	0.596

^{a,b}Means with superscript are significantly different at $p \leq 0.05$, [1]SEM: Standard errors of means, [2]p-value: Probability values, T1: *Ad libitum* feed, T2: Feed withdrawal from 11 am to 4 pm and T3: 1% palm oil added to control feed

Water treatment: Water treatment had no significant effect ($p<0.05$) on the growth performance of the birds. However, 'prekese' water improved the total feed intake, final body weight and the average body weight gain of broiler chickens in this study. This result showed that 'prekese' water increased the total feed intake of the birds and this showed the ability of *T. tetraptera* to stimulate appetite as well as improve feed intake. Similar results were reported by Essien[25] who showed that feed intake did not differ significantly between diets with different levels of *T. tetraptera* but increased as the level of *T. tetraptera* increased.

Interaction of feed and water treatments: Interaction of feed and water treatments had no significant effect on the overall growth performance of the birds. However, numerically total feed intake of birds in the T3*P2 interaction treatment group was higher (4869.72 g) than those of the other interaction groups. In agreement with the current results Das *et al.*[22] and Essien[25] noted that, the inclusion of palm oil in the diet of broilers improved its palatability and reduced its dustiness thereby increased the feed intake and also the feed intake did not differ significantly between diets with different levels of *T. tetraptera* but increased as the level of *T. tetraptera* increased. Also, T3*P2 had a better FCR Value (1.80) compared to the other treatments.

Carcass characteristics

Feed treatment: Table 7 shows the weight differentials of the various carcass components measured at the end of the study period. No significant differences ($p>0.05$) were recorded in

the live weight, bled weight, dressed weight, shank weight, neck weight, liver weight, heart weight, full and empty gizzard weight, full intestine, breast minor weight and abdominal fat weight of the birds in all the feeding treatments. With regards to the breast major weight (p = 0.0050) and full breast weight (p = 0.0222), significant differences were recorded among the feeding treatments. The breast major weight and full breast weight of birds in T3 were significantly higher (0.5125 and 0.6375 g), respectively than those in T1 and T2 treatments, whereas the weight of the breast major and full breast of T1 and T2 were not statistically different. This result concurs with a study conducted by Zhang *et al.*[26], when birds fed a diet containing oils had significantly heavier breast muscle than those of the control. Das *et al.*[23] reported that meat yield characteristics of broilers taking different palm oil levels in diets were not significantly different except for wing meat, gizzard and dark meat. Meanwhile, the inclusion of 4% canola oil and tallow mixture resulted in a significant increase in breast muscle and drumstick production.

Water treatment: No significant difference was recorded in carcass components measured under the water treatment (Table 7) in this study except for the head weight which recorded a significant difference (p = 0.0302). The highest head weight (67.17 g) was recorded for birds that had access to plain water. Also, empty gizzard weight among birds in the water treatments was significantly different (p = 0.0584). These results are similar to a previous study conducted by Essien[25] who observed that the weight of the internal organs (heart, kidney, gizzard and liver) had no significant variations across the treatments. The result indicated that *T. tetraptera* had no negative effect on the organs of the birds. This result is also consistent with a previous study by Amadbr and Zentek[27] who stated that inclusion of phytobiotic in diets of broiler chickens had no significant impact on the liver, heart and gizzard of broilers.

Interaction of feed and water treatments: The interaction of feed and water treatments (Table 8) had no significant influence on the carcass component except for full gizzard weight (p = 0.035) which recorded the highest weight (83 g) for T2*P1 birds followed by T3*P2 birds (69.25 g). T3*P1 birds recorded the least value (63 g) for the full gizzard weight. T1*P2 and T1*P1 birds had the same value for the full gizzard weight measured. The significant difference in full gizzard weight with T2*P1 birds having the highest value may the result of the interaction effect between feed withdrawal and "prekese" water which caused the birds to consume compensatory feed and consumption of more feed increased gizzard weight at the time of slaughter. Similarly, a significant increase in the relative weight of gizzard was reported in broiler chickens under feed restriction for 3 hrs during days 21-42[28]. Also, the full intestine weight tended to differ slightly (p = 0.054) between all the treatments with T1*P2 birds showed the highest weight (161.00 g) for full intestine and T3*P1 birds showed the least weight (123.25 g) for full intestine.

Hematological parameters

Feed treatment: A significant difference (p>0.05) was not observed for any of the hematological parameters measured at the end of the study, except for platelet (p = 0.0058), MVP (p = 0.0206) and PLCR (p = 0.0349) (Table 9). T3 birds had the highest platelet count (11500.00 K μL^{-1}) and the least count was in T1 birds (2000.00 K μL^{-1}). For MVP and PLCR, T1 birds had the highest count (10.15 fL and 30.08%), respectively. Although not statistically different, the white blood cells (WBC), red blood cells (RBC), HCT, RDWSD, RDWCV and hemoglobin (HGB) levels of the birds in T2 treatment were higher compared to birds in the other feeding treatments. According to Petek[29], hematocrit, hemoglobin and red blood cell levels were lower in the full-feed group than those in the 3-hour feed removal and 6 hours feed removal/day groups. While there were no significant differences in hematocrit and red blood cell levels between the treatments, the feed removal groups showed numerically higher concentrations in hematocrit and red blood cell levels.

Water treatment: Significant differences (p<0.05) were not observed for all the hematological parameters (Table 10) measured between the two water treatments except for MVP (p = 0.0460). In birds treated with "prekese" water, red blood cells and hemoglobin counts were higher than those treated with plain water. The high hemoglobin content in birds treated with "prekese" water is linked with the iron present in the prekese[17]. Furthermore, this also agrees with the findings of Bonsu *et al.*[30].

Interaction of feed and water treatments: The interaction of feed and water treatments showed no statistical differences (Table 10).

Blood lipid profile

Feed treatment: Table 11 shows the blood cholesterol profile of the birds under study. No significant differences were observed between all blood cholesterol components measured in the different feeding treatments. However, numerically, T2 and T3 birds had lower levels of TCHOL and

Table 7: Effects of feeding strategy and water treatment on carcass characteristics of broiler chickens (g bird^{-1})

Feeding strategy	Live weight	Bled weight	Dressed weight	Shank weight	Neck weight	Head weight	Liver weight	Heart weight	Full gizzard	Empty gizzard	Full intestine	Breast major	Breast minor	Full breast	Abdominal fat
Ad-libitum (T1)	2.780	2.530	2.120	95.50	114.130	63.000	51.380	12.630	66.130	46.130	142.750	0.42^{b}	0.120	0.540^{b}	19.130
Feed withdrawal (T2)	2.730	2.480	2.120	96.38	123.250	64.130	58.130	11.250	74.000	53.250	147.880	0.43^{b}	0.110	0.540^{b}	21.750
Ad-libitum+oil (T3)	2.930	2.630	2.310	94.63	122.630	60.750	56.130	11.750	66.130	46.000	125.000	0.52^{a}	0.130	0.640^{a}	20.000
SEM[1]	0.090	0.090	0.080	5.390	6.950	3.340	3.690	0.740	3.120	2.890	8.010	0.02	0.010	0.030	3.530
p-value[2]	0.262	0.461	0.151	0.974	0.593	0.771	0.431	0.434	0.148	0.157	0.135	0.005	0.697	0.022	0.868
Water															
Plain water (P1)	2.830	2.570	2.180	98.08	122.500	67.170^{a}	58.080	11.920	70.750	51.830	135.670	0.46	0.120	0.580	22.170
Prekese water (P2)	2.790	2.520	2.190	92.92	117.500	58.080^{b}	52.330	11.830	66.750	45.080	141.420	0.44	0.120	0.560	18.420
SEM	0.070	0.070	0.060	4.400	5.680	2.730	3.010	0.610	2.540	2.360	6.540	0.02	0.010	0.020	2.880
P-value	0.663	0.617	0.886	0.417	0.541	0.030	0.194	0.924	0.281	0.058	0.542	0.325	0.681	0.573	0.370

Means with superscripts are significantly different at p≤0.05, 1SEM: Standard error of means, 2P value: Probability values, T1: *Ad libitum* T2: Feed withdrawal from 11 am to 4 pm, T3: 1% palm oil added to feed

Table 8: Effects of interaction of feeding strategy and water treatment on carcass characteristics of broiler chickens (g bird^{-1})

Feeding strategy	Live weight	Bled Weight	Dressed weight	Shank weight	Neck weight	Head weight	Liver weight	Heart weight	Full gizzard	Empty gizzard	Full intestine	Breast major	Breast minor	Full breast	Abdominal fat
Interaction															
T1*P1	2.780	2.600	2.160	95.750	119.500	70.250	50.00	11.750	66.250^{b}	45.250	124.500	0.430	0.120	0.550	19.25
T1*P2	2.780	2.450	2.080	95.250	108.750	55.750	52.75	13.500	66.00^{b}	47.000	161.000	0.410	0.110	0.530	19.00
T2*P1	2.790	2.480	2.110	102.000	131.750	69.000	66.75	12.500	83.00^{a}	61.750	159.250	0.440	0.110	0.560	23.25
T2*P2	2.660	2.480	2.130	90.750	114.750	59.250	49.50	10.000	65.00^{b}	44.750	136.500	0.410	0.110	0.530	20.25
T3*P1	2.940	2.630	2.250	96.500	116.250	62.250	57.50	11.500	63.00^{b}	48.500	123.250	0.530	0.110	0.640	24.00
T3*P2	2.930	2.630	2.360	92.750	129.000	59.250	54.75	12.000	69.25^{b}	43.500	126.750	0.500	0.140	0.640	16.00
SEM	0.180	0.120	0.110	7.620	9.830	4.7300	5.22	1.050	4.410	4.090	11.330	0.030	0.020	0.040	5.00
p-value	0.864	0.774	0.645	0.773	0.304	0.4880	0.17	0.145	0.035	0.095	0.055	0.947	0.483	0.917	0.738

Means with superscripts are significantly different at p≤0.05, 1SEM: Standard error of means, 2P value: Probability values, T1: *Ad libitum* T2: Feed withdrawal from 11 am to 4 pm, T3: 1% palm oil added to feed

Table 9: Effects of feeding strategy and water treatments on haematological indices of broiler chickens

Feeding strategy	WBC (K µL^{-1})	RBC (K µL^{-1})	HGB (g dL^{-1})	HCT (%)	MCV (fL)	MCH (pg cell^{-1})	MCHC (g dL^{-1})	PLT (K uL^{-1})	NEUT (K µL^{-1})	RDWSD (fL)	RDWCV (%)	MVP (fL)	PLCR (%)
Ad-libitum (T1)	189200	2467500	9.58	34.8	141.6	38.9	27.5	2000^{b}	56775	59.4	13.9	10.15^{a}	30.1^{a}
Feed withdrawal (T2)	195425	2637500	9.75	36.3	137.9	37.0	26.9	6250^{ab}	150750	64.0	16.3	9.93^{ab}	29.2^{ab}
Ad-libitum+oil (T3)	185375	2270000	9.05	32.5	143.4	39.9	27.8	11500^{a}	53050	58.4	15.2	9.03^{b}	20.7^{b}
SEM[1]	3962	109541	0.47	1.17	2.21	0.81	0.50	1237	54694	6.48	1.19	0.207	1.90
p-value[2]	0.311	0.162	0.58	0.16	0.312	0.146	0.470	0.006	0.468	0.837	0.437	0.021	0.035
Water													
Plain water (P1)	190817	2455000	9.40	34.8	142.1	38.5	27.1	7666	103717	64.8	14.7	10.0^{a}	26.9
Prekese Water (P2)	189183	2461666	9.52	34.3	139.8	38.7	27.7	5500	70000	56.4	15.5	9.38^{b}	26.4
SEM	3242	89643	0.385	0.953	1.805	0.659	0.409	1013	44759	5.305	0.977	0.169	1.67
p-value	0.737	0.960	0.839	0.770	0.413	0.787	0.325	0.192	0.618	0.315	0.589	0.046	0.816

[a,b]Means with superscript are significantly different at p≤0.05, 1SEM: Standard errors of means;, 2P value: Probability values T1: *Ad-libitum* feed, T2: Feed withdrawal from 11 am to 4 pm, T3: 1% palm oil added to control feed, WBC: White blood cells, RBC: Red blood cell, HGB: Haemoglobin, HCT: Haematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration;, PLT: Platelet;, NEUT: Neutrophils;, RDWSD: Red cell distribution width standard deviation, RDWCV: Red cell distribution width coefficient of variation, MPV: Mean platelet volume, PLCR: Platelet large cell ratio

Table 10: Effects of interaction of feeding strategy and water treatments on haematological indices of broiler chickens

Feeding strategy	WBC (K µL^{-1})	RBC (K µL^{-1})	HGB (g dL^{-1})	HCT (%)	MCV (fL)	MCH (pg cell^{-1})	MCHC (g dL^{-1})	PLT (K uL^{-1})	NEUT (K µL^{-1})	RDWSD (fL)	RDWCV (%)	MVP (fL)	PLCR (%)
Interaction													
T1*P1	184600	2265000	9.00	33.3	146.8	39.7	27.1	2000	7800	59.5	12.7	10.8	30.6
T1*P2	193800	2670000	10.2	36.4	136.3	38.0	27.9	2000	105750	59.3	15.1	9.6	29.6
T2*P1	203300	2870000	10.4	39.2	136.6	36.2	26.5	7000	203300	80.4	17.1	10.3	31.5
T2*P2	187550	2405000	9.10	33.5	139.1	37.9	27.2	5500	98200	47.6	15.5	9.55	26.9
T3*P1	184550	2230000	8.80	31.8	142.9	39.5	27.7	14000	100050	54.6	14.4	9.00	18.8
T3*P2	186200	2310000	9.30	33.2	144.0	40.3	28.0	9000	6050	62.3	16.0	9.05	22.6
SEM	5572	154067	0.661	1.64	3.10	1.13	1.19	1740	76926	9.12	1.68	0.272	2.88
p-value	0.193	0.105	0.288	0.109	0.154	0.374	0.928	0.369	0.384	0.185	0.547	0.161	0.426

[a,b]Means with superscript are significantly different at p≤0.05, 1SEM: Standard errors of means, 2P value: probability values, T1: *Ad libitum* feed, T2: Feed withdrawal from 11 am to 4 pm, T3: 1% palm oil added to control feed; WBC: White blood cells, RBC: Red blood cell, HGB: Haemoglobin, HCT: Haematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, PLT: Platelet, NEUT: Neutrophils, RDWSD: Red cell distribution width standard deviation, RDWCV: Red cell distribution width coefficient of variation, MPV: Mean platelet volume, PLCR: Platelet large cell ratio

Table 11: Effect of feeding strategy and water treatments on some blood lipid profile of broiler chickens

Source	TCHOL (mmol L^{-1})	TG (mmol L^{-1})	HDL (mmol L^{-1})	LDL (mmol L^{-1})	VLDL (mmol L^{-1})
Feeding strategy					
Ad-libitum (T1)	3.240	0.800	1.900	0.850	0.370
Feed withdrawal (T2)	3.010	0.850	1.600	1.000	0.390
Ad-libitum+oil (T3)	2.750	0.650	1.600	0.850	0.300
SEM[1]	0.547	0.454	0.321	0.431	0.208
p-value[2]	0.832	0.950	0.775	0.961	0.951
Water					
Plain water (P1)	2.920	0.500	1.770	0.830	0.230
Prekese water (P2)	3.070	1.030	1.630	0.970	0.470
SEM	0.446	0.370	0.262	0.352	0.170
p-value	0.834	0.416	0.754	0.814	0.418

SEM: Standard error of means, p-value: Probability values, T1: *Ad-libitum* feed, T2: Feed withdrawal from 11 am to 4 pm, T3: 1% palm oil added to feed, VLDL: Very low-density lipoprotein, LDL: Low-density lipoprotein, HDL: High density lipoprotein, TCHOL: Total cholesterol and TG: triglycerides

HDL. Increased dietary energy levels increased HDL cholesterol and triglyceride levels[31]. Non significant effect observed in the present study could be attributed to the lower level of palm oil included in treatment T3. This result confirms the results of a study by Zhang *et al.*[32] who stated that addition of 2% olive oil in diets, had no significant impact ($p>0.05$) on the total cholesterol and HDL-cholesterol concentration levels in broilers. Some researchers have reported that feed restrictions contributed to a rise in the overall blood cholesterol level compared to *ad libitum* feeding while others have no reports on this effect[33-35]. It has also been observed that blood VLDL and HDL cholesterol levels at 42 days of age were not affected by feed restriction at 25 and 50% *ad libitum* and this agrees with the study of Jahanpour *et al.*[36]

Water treatment: Table 11 shows that the values for the water treatment were not significantly different during the entire study. Birds treated with 'prekese' water had higher values of total cholesterol (TCHOL), triglycerides (TG), low-density lipoprotein (LDL) and Very low-density lipoprotein (VLDL) than those treated with plain water. However, birds treated with "prekese" water had a lower level of HDL than those treated with the plain water.

CONCLUSION AND RECOMMENDATIONS

High ambient temperatures negatively affect the performance of broilers by reducing feed intake and increasing mortalities. Feeding strategies, for instance, organic anti-stressors supplementation, *Tetrapluera tetraptera* ("prekese") feed withdrawal and the addition of 1% palm oil have been found to enhance feed intake, growth performance and welfare and meat quality and did not have any adverse effect on the internal organs of the chickens during hot weather. However, the effectiveness of these practices will differ depending on several factors including, the class and age of birds, relative humidity and air velocity, the duration and the intensity of heat, level of palm oil inclusion and the level of *Tetrapluera tetraptera* (Prekese) inclusion in water. The hot periods are critical for poultry production and these feeding strategies will support the profitability of poultry farms. The results of this study showed that birds fed diets supplemented with 1% palm oil with "prekese" water had the highest body weight gain. However, no detrimental effect was observed on the general hematological and carcass characteristics of the broilers. Based on the results obtained in this study, it is recommended that further experiments could be conducted at different levels of palm oil inclusion in the diet and of the "prekese" in water to establish the optimum inclusion levels that would elicit a positive growth performance of birds and the specific phytochemicals that are responsible for the medicinal properties concerning heat stress, meat quality and welfare of the birds as well as the cost-effectiveness of different levels of their inclusion in broiler drinking water.

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