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ORIGINAL RESEARCH ARTICLE

Water pH influence on the performance, blood and carcass indices of broiler chickens

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ABSTRACT

This study was carried out to determine the optimum water pH range suitable for optimum performance and wellbeing of broiler chickens. Borehole water with pH of 6.85 was differently basified and acidified with Calcium oxide (CaO) and Citric acid (C_5H_7COOH) respectively to achieve pH levels; 5.5, 6.0, 6.5, 7.0, 7.5, 8.0 and 8.5 as experimental treatments. Two hundred and ten (210) day-old Mashall Broiler-Chicks were used as experimental units. The chicks, with average weight of 55g were randomly assigned into seven treatments of pH levels; T1 (5.5), T2 (6.0), T3 (6.5), T4 (7.0), T5 (7.5), T6 (8.0) and T7 (8.5) with three replicates per treatment. The replicates were of 10 chicks each. The chicks were brooded and raised in equi-dimensional pens (1m x 1m). The birds under each treatment were fed the same commercial broiler starter (22% CP and 2900 kcal/Kg ME) and finisher (18% CP and 2900 kcal/Kg ME) diets and allowed to consume the feed and the waters *ad-libitum*. The trial lasted 8 weeks, during which the records on average weekly weight gain, average daily water and feed consumption were kept. At the end of the 8 weeks, two birds from each replicate were sacrificed for carcass parameters and blood collected for haematological indices**.** Birds under pH 6.5 had the highest weight gain (418.75± 8.83g/bird) at week 8 and relatively high weight gain (57.95±3.74g/bird) in week 1 under pH 6.0. Feed intake decreases as the pH increases with highest feed intake (737.50±17.67g/bird) being recorded at week 8 under pH 7.0. Water intake decreases as the pH increases. The least Feed conversion ratio value (1.72±0.03) was at week 8. Organs were significantly influenced by the treatments. This study concluded that pH range of 5.5 to 6.5 as pH range for optimum performance of broiler chickens.

Keywords: Feed intake, pH level, water intake, weight gain

INTRODUCTION

Water is the most critical nutrient that we consciously supply to birds (Leeson and Summer, 1997). This tends to reveal the pioritised relevance of water in the wellbeing and performance of poultry chickens. Water consumption is important to broiler performance and care should be taken not to inhibit the bird's ability to drink. Bird's water intake depends on feed intake, ambient temperature and salt/mineral content (Jan Hulzenbosch, 2004). Mc Donald *et al.* (2002) mentioned that water is vital to the life poultry birds; they will die more rapidly if deprived of water than deprived of feed. Water helps to maintain homeostasis by participating in reactions and physiological changes which control pH, osmotic pressures, electrolyte concentrations and other functions necessary for life (Scott *et al*., 1982). Water is involved in many aspects of poultry metabolism including body temperature control, food digestion and absorption, nutrients transport, and waste products elimination from the body (Jafari *et al*., 2006). Birds consume approximately 1.6-2.0 times as much water as feed on a weight basis (Kellems and Church, 2002); therefore, any deviation in water quality could have a more pronounced effect on poultry health and production than feed did. Drinking water is of concern to poultry producers due to its great variability in quality and its potential for contamination (Abbas *et al*., 2008). Several physico-chemical parameters has been established as an indicator of water quality such as taste, color, odour, pH, electrical conductivity (EC), hardness, alkalinity, salinity, and presence of cations and anions (Zimmermann and Douglass ,1998). High-quality drinking water has

been defined as water that contains inclusions, which promote vitality and lack inclusions causing morbidity and mortality (Zimmermann and Douglass, 1998). Naturally, Water is not 100% pure; hence different water sources will have varying degree of water inclusions, which directly or indirectly affect poultry performance and welfare. However, Asaniyan *et al*. (2012) reported that sources of water had no detrimental effect on the wellbeing of broiler chickens. Therefore, poor handling of water and discharge of pollutants into a water source or course compromised water quality and not necessarily the source. Water consumption can be limited if the water is too hot or is contaminated with excess minerals. Water and food consumption rates are interdependent, so reduced water intake can also lead to reduced food intake. There are other factors that affect water intake, with temperature being the most obvious one. Water intake is also affected by the type of drinkers used. The rule of thumb for water intake is that water intake is usually 1.5 to 2 times feed intake. Water pH of less than 5.9 was harmful to bird performance (Carter, 1987). However, Watkins *et al*. (2004) reported that lowered pH of drinking water to 3, 4 or 5 had no significant improvement on average weights, feed conversion or water consumption of broiler chicken. This tends to show that birds are very tolerant to a wide range of pH water. The current recommendation for poultry water pH is within a range of 6 to 6.5 (McCoy, 2011). Birds have been shown to be tolerant of lower pH levels; however, a pH of 5 or lower can corrode metal (Watkins, 2008).

Water quality attributes can have a direct or indirect effect on performance. Key water quality factors affecting water intake on poultry farms include pH, hardness and total dissolved solids (Tabler *et al*., 2013). The pH of water is a measure of its acidity or alkalinity. A numeric scale for measuring pH runs from 1 to 14. Neutral water (neither acid nor alkaline) has a pH of 7. Acidic water has a pH lower than 7; if pH is greater than 7, water is alkaline or basic (Tabler *et al*., 2013). Hardness refers to the presence of dissolved minerals such as calcium and magnesium in either bicarbonate or sulfate form and is expressed as an equivalent of calcium carbonate. It measures the tendency of water to precipitate soap and form scale. Hard water is commonly associated with the buildup of deposits and the formation of scale in the components of the watering system. Hardness is not commonly harmful to poultry unless certain ions are present in toxic amounts. High levels of Total Dissolved Solids (TDS) cause the most harmful effects in poultry production (Brake and Hess, 2001). However, research shows that pH is a major factor in determining the amount of drinking water that birds consume (Zoetis, 2013). Anything that reduces their water intake will have an adverse effect on their feed intake (McCoy, 2011). Consequently, broiler performance and welfare could be compromised. The challenge of indiscriminate disposal of waste predisposed the major sources of water to pollution. This tends to make treatment an inevitable task; especially livestock farmers that realized the sensitive position of water in nutritional performance of animals but unfortunately, majority of the farmers lack the capacity to embark on low scale water treatment. Some engaged in adding various cheap and affordable items to achieve sedimentation, population and potency reduction of injurious organisms. This tends to subject the drinking water to fluctuated pH. Therefore, this study tends to examine the effects of water pH on broiler performance, blood and carcass indices.

The experiment was carried out at the Poultry Unit of Teaching, Research and Entrepreneurial Farm of Joseph Ayo Babalola University, Ikeji Arakeji, Osun State, Nigeria. The experiment lasted for eight weeks.

Experimental water: The water used in this study was borehole water with pH of 6.85. The fetched borehole water was then prepared into experimental pH levels in the Chemistry Laboratory of Joseph Ayo Babalola University. The water was differently basified and acidified with Calcium oxide (CaO) and Citric acid (C_5H_7COOH) respectively; using pH meter to establish the levels. The pH levels were 5.5, 6.0, 6.5, 7.0, 7.5, 8.0 and 8.5.

Management of chicks and Experimental lay-out: Two hundred and ten (210) day-old Mashall Broiler-Chicks used were purchased from a commercial hatchery; Muogal Farm. The chicks, with average weight of 55g were randomly assigned into seven treatments of pH levels; T1

(5.5), T2 (6.0), T3 (6.5), T4 (7.0), T5 (7.5), T6 (8.0) and T7 (8.5) with three replicates per treatment. The replicate size was thirty (30) chicks per replicate. The chicks were brooded and raised in equi-dimensional pens (1m x 1m). The birds under each treatment were fed the same commercial broiler starter (22% CP and 2900 kcal/Kg ME) and finisher (18% CP and 2900 kcal/Kg ME) diets and allowed to consume the waters with different pH levels *ad-libitum*. The routine medication and vaccination programme as outlined by the University Teaching and Research farm were observed for the birds. The trial lasted 8 weeks, during which the records on average weekly weight gain, average daily water and feed consumption were kept.

Carcass and organ Parameters: Two birds were randomly selected for carcass and organ parameters. After slaughtering and bleeding, the carcasses were scalded at 65^0C in water bath for 30seconds before defeathering. The dressed chickens were later eviscerated. The carcass parameters measured during this study included (%) dressed weight, (%) eviscerated weight, thigh, drumstick, shank, breast, upper back, lower back, wing and head. Visceral organs evaluated were liver, kidney, lungs, heart, gizzard, spleen and pancreas. All the carcass characteristics as well as the organs measured were expressed in g/kg body weight except the dressed and eviscerated weights, which were expressed as percentages of the body weights.

Blood Collection and haematological Analysis: At the end of the trial, the randomly selected chickens per replicate were weighed and sacrificed by severing their jugular vein with a sharp surgical knife. The blood was then allowed to flow freely into labelled bijour bottles containing an anticoagulant, Ethylene diamine tetra-acetic acid (EDTA) to prevent clotting were used for the determination of haematological parameters. The packed cell volume (PCV), total red blood cells count (RBC) and white blood cell counts (WBC) were determined by methods outlined by Schalm *et al*. (1975). Total white blood cell (WBC) count was determined with a Neubauer haemocytometer using the WBC diluting fluid described by Blaxhall and Daisley (1973).

Statistical Analysis: All data collected were subjected to one way analysis of variance (ANOVA) using SPSS (2010) Version 17. Duncan's Multiple Range Tests (DMRT) was used to compare the means.

RESULTS

Performance record: Tables 1 to 4 present the performance indices for the broiler chickens exposed to the experimental treatments (seven water pH levels). The performance indices; weight gain, feed intake, water intake and feed conversion ratio were generally decreasing as the pH levels increases. In table 1 there were significant ($P<0.05$) effects of the treatments on weekly cumulative weigh gain among the treatments at weeks 1, 5, 6 and 8. However, the weight gain reduces as the pH levels increases with the highest weight gain (418.75± 8.83g/bird) under treatment T3 (pH 6.5) at week 8 and relatively high weight gain (57.95±3.74g/bird) in the early age of week 1 was recorded under treatment T2 (pH 6.0). In table 2 there were significant ($P<0.05$) effect of the treatments on the feed intake at weeks 2, 7 and 8. The feed intake decreases as the pH increases with highest feed intake (737.50±17.67g/bird) being recorded at week 8 under treatment T4 (pH 7.0) but not significantly ($P>0.05$) different from feed intake in treatments T1, T2, T3 and T5. Except for weeks 2 and 3; Water intake was significantly ($P<0.05$) affected by the treatments as shown in table 3. The water intake decreases as the pH increases. Except at weeks 2, 3 and 7; feed conversion ratio (FCR) of the broiler chickens was significantly ($P<0.05$) influenced by the water pH. The FCR increases in magnitude as the water pH increases; with the least FCR value (1.72±0.03) at week 8 indicates optimal utilization of feed under treatment T3 (pH 6.5) by the broiler chickens. However, T3 was not significantly ($P>0.05$) different from other treatments except treatment T7 (2.77±0.38); on which the birds poorly utilized feed at week 8.

Carcass, organ and blood parameters: Table 5 presents carcass parameters of broilers reared on different water pH. Treatment effects on carcass parameters were not significant ($P>0.05$); except for the shank, wing, live weight and bled weight.

Table 1: Mean weekly cumulative weight gain (g/bird) of broilers reared on different water pH

	Water pH Levels						
Age (week)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
0	53.13±4.41	50.0±0.00	56.25±0.00	53.12±4.41	53.1±24.41	56.25±0.0	50.0±0.0
1	103.15±6.92	107.95±3.74	111.55±0.98	109.02 ±0.38	108.12 ±3.28	104.7±0.21	104.65±4.31
2	250.85^{bc}±0.28	260.75^{a}±0.63	256.70^{ab}±6.57	260.72^{a}±0.31	254.62^{abc}±0.45	249.90^{c}±0.07	249.95^{c} ± 0.0
3	416.40^{ab}±3.18	427.25^{ab}±17.46	413.60^{ab}±17.32	431.02^{a}±6.75	413.02^{ab}±6.75	402.15^{b}±3.67	413.65^{ab}±3.46
4	616.85^{ab}±24.18	646.40^{a}±6.64	622.40ab±25.10	644.67a±17.85	625.72ab±3.42	596.30b±26.65	642.30ab±8.48
5	782.00^{a}±7.42	785.40^{a}±102.24	722.40^{ab}±7.42	750.92^{ab}±26.69	725.72^{ab}±3.42	646.30^{b}±62.01	729.80^{ab}±26.87
6	900.75^{ab}±86.97	1047.90^{a}±84.56	947.40^{a}±27.93	988.42^{a}±115.08	875.72^{ab}±56.46	727.55^{b}±88.52	873.55^{ab}±71.06
7	1057.00^{ab}±78.13	1204.15^{a}±164.11	1078.65^{ab}±89.80	1169.90^{a}±88.24	1106.97^{ab}±47.62	933.80^{b}±79.69	1054.80^{ab}±9.19
8	1438.25^{ab}±36.76	1579.15^{a}±181.79	1497.40^{ab}±80.96	1526.95^{ab}±61.73	1444.47^{ab}±65.30	1296.30^{b}±115.04	1304.80^{b}±26.16

a,b,c: Means with different superscript in the same row are significant (P<0.05)

T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

Table 2: Mean weekly cumulative feed intake (g/bird) of broilers reared on different water pH

	Water pH Levels						
Age (weeks)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
1	72.35±2.61	83.00±3.53	88.70±2.96	75.90±11.87	83.30±12.7	73.15±3.32	82.80±10.18
2	303.60±11.45	308.00±3.53	313.70±2.96	294.65±20.71	295.80±12.72	291.90±5.51	289.05±1.34
3	547.35^{a}±2.61	545.50^{ab}±14.41	551.20^{a}±14.70	532.15^{ab}±3.04	533.30^{ab}±4.94	548.15^{a}±3.52	526.55^{b}±1.34
4	953.60±46.81	989.25±22.98	988.70±14.70	935.65±15.76	951.05±30.05	948.15±38.67	951.55±19.02
5	1579.20±46.81	1583.30±21.63	1626.50±31.96	1607±20.71	1563.55±12.37	1541.90±82.87	1539.05±72.05
6	2204.20±46.81	2189.55±48.15	2251.50±31.96	2232.15±20.71	2188.55±12.37	2140.90±119.64	2164.05±72.05
7	2885.45^{ab}±37.97	2883.30^{ab}±56.99	2970.25^{a}±40.80	2969.65^{a}±20.71	2919.80^{ab}±38.89	2816.90^{b}±82.87	2820.30^{b}±27.86
8	3604.20^{ab}±29.13	3595.80^{ab}±56.99	3695.25^{a}±40.80	3707.15^{a}±38.39	3632.30^{ab}±21.21	3523.15^{b}±91.71	3507.80^{b}±27.86

a,b,c: Means with different superscript in the same row are significant (P<0.05)

T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

Similarly, except for lung and liver; all the organs were significantly (P<0.05) influenced by the treatments (Table 6). Treatment effects on blood parameters were not significant (P>0.05) (Table 7).

Table 3: Mean weekly cumulative water intake (litre/bird) of broilers reared on different water pH

	Water pH Levels						
Age (weeks)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
1	$0.21^{b}\pm0.00$	$0.20^{b}\pm0.00$	$0.22^{a}\pm0.00$	$0.17^{c}\pm0.00$	$0.17^{c}\pm0.00$	$0.16^{cd}\pm0.00$	$0.15^{d}\pm0.02$
2	$0.61^{a}\pm0.00$	$0.60^{ab}\pm0.00$	$0.63^{a}\pm0.02$	$0.61^{a}\pm0.00$	$0.58^{ab}\pm0.04$	$0.55^{b}\pm0.01$	$0.55^{b}\pm0.01$
3	$1.22^{b}\pm0.00$	$1.33^{a}\pm0.00$	$1.35^{a}\pm0.00$	$1.33^{a}\pm0.00$	$1.24^{b}\pm0.04$	$1.15^{c}\pm0.01$	$1.11^{c}\pm0.01$
4	$2.04^{b}\pm0.00$	$2.20^{a}\pm0.00$	$2.24^{a}\pm0.01$	$2.22^{a}\pm0.02$	$2.08^{b}\pm0.03$	$1.95^{c}\pm0.01$	$1.87^{d}\pm0.01$
5	$3.35^{c}\pm0.00$	$3.51^{b}\pm0.00$	$3.56^{a}\pm0.01$	$3.54^{a}\pm0.02$	$3.37^{c}\pm0.01$	$3.10^{d}\pm0.01$	$2.99^{c}\pm0.01$
6	$4.66^{c}\pm0.01$	$4.82^{b}\pm0.00$	$4.88^{a}\pm0.01$	$4.86^{a}\pm0.02$	$4.67^{c}\pm0.01$	$4.35^{d}\pm0.00$	$4.24^{c}\pm0.01$
7	$6.41^{ab}\pm0.01$	$6.50^{a}\pm0.00$	$6.37^{ab}\pm0.19$	$6.23^{b}\pm0.02$	$6.04^{c}\pm0.09$	$5.60^{d}\pm0.01$	$5.49^{d}\pm0.01$
8	$8.13^{ab}\pm0.05$	$8.25^{a}\pm0.00$	$8.12^{ab}\pm0.19$	$8.01^{b}\pm0.02$	$7.57^{c}\pm0.05$	$6.97^{d}\pm0.00$	$6.86^{d}\pm0.01$

a,b,c: Means with different superscript in the same row are significant (P<0.05)
T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

Table 4: Mean weekly cumulative feed conversion ratio of broilers reared on different water pH

	Water pH Levels						
Age (weeks)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
1	1.44±0.02	1.43±0.15	1.60±0.02	1.35±0.09	1.51±0.26	1.50±0.07	1.52±0.30
2	1.56±0.13	1.47±0.02	1.54±0.07	1.43±0.06	1.45±0.02	1.50±0.06	1.41±0.10
3	1.47±0.08	1.43±0.26	1.50±0.00	1.39±0.16	1.49±0.00	1.68±0.09	1.44±0.03
4	2.05±0.50	2.03±0.18	2.09±0.07	1.93±0.09	1.96±0.24	2.07±0.14	1.85±0.17
5	3.85±0.74	5.74±4.27	6.48±1.30	6.25±0.35	6.12±0.17	5.29±4.29	7.17±2.29
6	$6.78^{ab}\pm4.54$	$2.31^{b}\pm0.05$	$2.81^{ab}\pm0.44$	$2.82^{ab}\pm1.05$	$4.44^{ab}\pm1.56$	$7.72^{a}\pm2.08$	$4.56^{ab}\pm1.40$
7	4.36±0.19	5.11±2.66	6.17±2.97	4.10±0.60	3.15±0.01	2.59±0.74	3.79±1.05
8	1.93±0.52	$1.89^{ab}\pm0.09$	$1.72^{ab}\pm0.03$	$2.06^{ab}\pm0.22$	$2.11^{ab}\pm0.05$	$1.95^{ab}\pm0.16$	$2.77^{a}\pm0.38$

a,b,c: Means with different superscript in the same row are significant (P<0.05)
T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

DISCUSSION

Overview of the performance parameters (weight gain, feed intake, water intake and feed conversion ratio) revealed isolated significant effect of the treatments at the finisher stage. Such was not observed at the earlier stage of growth. However, treatment effect on feed consumption for pH 7.0 (T4) was significantly different from every other treatments. The trend expressed in this work showed that water intake for broiler chicken is optimum at slightly acidic towards neutral and slightly alkaline pH. Hence, supporting the fact that birds could tolerate lower pH levels; however, a pH of 5 or lower can corrode metal (Watkins, 2008). Feed conversion ratio was not significantly different among the treatment means except T7 at week 8 which was different having the highest value. This trend expressed a better utilization of feed among the treatments at low pH values. This could be attributed to the decreasing trends of feed intake, water intake and weight gain as the pH increases. Therefore, treatment T3 (pH 6.5) gave the optimum utilization of feed by the broiler chickens. This tends to fall within the water pH range recommended for poultry (McCoy, 2011). This pH range has been

reported to improve the efficacy of vaccines, antibiotics and antimicrobials administered through water system and also help reduce scale and biofilm buildup in the system (McCoy, 2011). Even though, isolated significant differences were observed among the treatment means for the carcass and organ parameters; the carcass and organ growth were optimal at lower pH levels. This shows that carcass and organ growth responded directly to the treatment influence on the performance of broiler chickens. However, the non significant influence of treatments on the considered blood parameters indicated that the pH levels had no detrimental effects on the health wellbeing of the broiler chickens.

CONCLUSION

This study revealed that increasing pH levels (alkalinity) and decreasing pH levels supported better and poor performance of broiler chickens respectively. Also, within the limit of this study; pH levels had no direct effect on the health wellbeing of the broiler chickens. Therefore, this study presents pH range of 5.5 to 6.5 as pH range for optimum performance of broiler chickens. However, the fact that birds could tolerate lower pH levels and that a pH of 5 or lower can corrode metal; Proper maintenance of water supply system is of necessity where metals are used or alternatively, not easily corroded facilities could be used for water supply system in poultry farms.

Conflict of Interest Statement

This study was personally conducted and funded by the researcher. There is no any form of external support towards this work. Therefore, the researcher envisages no conflict of interest from anyone.

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Table 5: Carcass parameters of broilers reared on different water pH

	Water pH Levels						
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Live weight (kg)	1.46^{ab}±0.07	1.46^{ab}±0.04	1.52^{a}±0.12	1.47^{a}±0.06	1.40^{ab}±0.06	1.40^{ab}±0.01	1.29^{b}±0.00
% Bled weight	95.95^{ab}±1.06	96.00^{ab}±0.00	95.85^{ab}±0.91	94.70^{b}±0.84	96.40^{ab}±0.70	96.95^{a}±0.63	95.50^{ab}±0.42
%Plucked weight	93.70±0.56	93.53±0.63	92.80±0.84	92.15±2.19	93.50±0.42	93.55±0.21	92.40±0.98
% Dressed weight	63.30±2.26	62.40±0.70	62.20±0.28	62.65±1.48	62.05±2.61	63.65±0.07	61.8±1.27
% Eviscerated weight	75.10±0.56	76.80±0.70	76.35±0.21	76.35±2.19	74.65±2.75	76.30±0.14	73.50±0.00
Head (g/kg body weight)	28.00±2.26	30.90±2.68	30.40±1.69	29.55±0.07	34.72±7.60	29.95±0.35	29.80±2.82
Neck “	52.50±4.52	50.45±0.21	51.25±0.63	56.40±2.12	51.00±7.07	54.00±4.80	54.05±15.34
Wing ”	106.25^{a}±2.33	85.95^{b}±0.63	92.15^{ab}±6.15	92.95^{ab}±4.87	93.20^{ab}±9.19	91.50^{ab}±12.02	94.10^{ab}±11.31
Chest ”	151.35±16.89	170.85±21.84	166.30±14.99	154.75±13.78	145.25±11.52	168.20±12.58	144.50±6.50
Upper back ”	58.65±9.54	64.35±7.84	58.60±6.64	63.50±2.26	73.10±19.23	63.55±0.91	66.50±6.85
Lower back ”	80.40^{ab}±2.54	94.50^{a}±10.46	75.20^{b}±1.55	97.40^{a}±4.66	91.55^{ab}±12.94	84.05^{ab}±2.47	88.90^{ab}±3.53
Thigh ”	107.45±3.32	109.10±0.98	113.05±7.99	103.35±2.75	108.50±10.04	105.50±3.39	111.45±8.13
Drumstick ”	103.70±4.94	96.75±11.66	101.45±4.03	96.75±6.43	109.70±2.40	107.90±1.97	105.30±5.65
Shank ”	45.25^{b}±0.07	46.50^{b}±0.28	46.30^{b}±2.26	48.10^{ab}±6.64	57.70^{a}±0.56	56.60^{a}±4.10	52.65^{ab}±6.15

a,b,c: Means with different superscript in the same row are significant (P<0.05)

T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

Table 6: Organ parameters of broilers reared on different water pH

	Water pH Levels						
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Heart(g/kg body weight)	5.70^{a}±1.13	4.70^{ab}±0.84	3.85^{b}±0.63	4.70^{ab}±0.14	4.35^{ab}±0.35	4.20^{ab}±0.00	4.20^{ab}±0.56
Lung(g/kg body weight)	5.35±1.62	6.75±0.77	6.45±0.35	7.2±0.00	6.05±0.21	6.70±0.56	5.70±0.56
Liver(g/kg body weight)	20.4±0.98	23.35±2.75	22.40±1.41	21.80±2.82	19.90±1.55	20.55±0.07	22.75±0.49
Kidney(g/kg body weight)	6.75a±0.63	5.75ab±0.63	3.60c±1.69	6.00ab±0.84	5.72ab±1.62	5.65ab±0.07	5.75ab±1.62
Gizzard(g/kg body weight)	44.95^{ab}±5.02	48.60^{a}±3.67	41.50^{ab}±1.97	34.65^{b}±7.84	38.25^{ab}±3.88	39.10^{a}±6.22	38.90^{ab}±6.08
Pancreas(g/kg body weight)	2.00±0.14	2.30±0.42	1.90±0.14	2.20±0.56	2.65±0.07	3.15±0.49	2.65±0.49
Spleen(g/kg body weight)	0.65^{ab}±0.07	0.60^{b}±0.00	0.60^{b}±0.00	0.60^{b}±0.00	0.60^{b}±0.00	0.70^{a}±0.00	0.70^{a}±0.00
Proventriculus (g/kg body weight)	6.40±0.14	4.35±0.35	5.20±0.42	5.10±2.12	6.35±0.21	6.00±0.56	4.20±0.56

a,b,c: Means with different superscript in the same row are significant (P<0.05)

T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

Table 7: Blood parameters of broilers reared on different water pH

	Water pH Levels						
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Haemoglobin (gm/100ml)	9.50±1.13	8.55±2.05	9.50±0.28	10.05±0.07	8.80±3.52	7.40±2.40	8.70±2.82
Packed Cell Volume (%)	28.50±3.53	25.50±6.36	28.50±0.70	30.00±0.00	26.50±10.60	22.00±7.07	26.00±8.48
WBC (mm^3)	6350.00±2050.60	7250.00±2333.45	6850.00±636.39	5750.00±70.71	7100.00±2687.00	7850.00±2192.03	7150.00±2757.71
RBC (x $10^6/mm^3$)	3.15±0.35	2.67±0.45	3.15±0.07	3.17±0.17	2.95±1.13	2.47±0.74	2.90±0.91

Mean±SD, RBC: Red Blood Cell, WBC: White Blood Cells

T1= Water pH 5.5, T2= Water pH 6.0, T3= Water pH 6.5, T4= Water pH 7.0, T5= Water pH 7.5, T6= Water pH 8.0 and T7= Water pH 8.5,

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