EFFECT OF DIFFERENT SOURCES OF DRINKING WATER ON THE GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, AND HEMATOLOGICAL INDICES OF BROILER CHICKENS

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ABSTRACT
This present study was conducted to evaluate the implications of different sources of drinking water on growth performance, carcass characteristics, and haematological indices of broilers. Treatments consisted of three different water sources at the College of Agriculture and Natural Resources (CANR), KNUST, Kumasi. Treatment one (T1) was water from a borehole at the Poultry Section of the Department of Animal Science designated as borehole 1, treatment two (T2) was water from another borehole at the Poultry Section of the Department of Animal Science, designated as borehole 2 and treatment three (T3) was tap water from the faculty of Renewable Natural Resources (FRNR). Analysis was conducted on the water samples to determine heavy metal concentration levels in the three sources of drinking water for broilers. A total of 192 Ross 308 broiler day-old chicks were used for the experiment in a Completely Randomized Design (CRD), with three treatments and four replicates per treatment. Sixty-four (64) birds were assigned to each treatment, with 16 birds per replicate. The quantity of feed consumed and water intake were measured daily and averages were calculated weekly for six weeks. At the end of the experiment, blood samples were collected from the wing vein of 12 birds selected randomly, one per replicate for haematological analysis, and two birds were also selected from each replicate for carcass characteristics. Data obtained were analyzed using the General Linear Model procedure of Minitab Version 18. Significant differences between means were set at $p<0.05$, and differences between treatment means were separated using Tukey's Studentized Range Test. The results show that the levels of heavy metals were within acceptable range. Growth performance and most of the carcass characteristics were not affected by the three drinking water treatments ($p>0.05$). Birds on tap water had the highest neck weight compared to those on boreholes 1 and 2 ($p<0.05$). Birds offered water from boreholes 1 and 2 recorded the highest abdominal fat content as compared to the birds that were given tap water ($p<0.05$). Haematological indices were not different among broilers from the three treatments ($p>0.05$). In conclusion, all three drinking water sources used in this study did not have any marked negative effects on the growth performance, carcass characteristics and haematological indices of broilers.

Keywords: *Borehole, contaminants, heavy metals, minerals, tap water*

INTRODUCTION

Poultry is one of the main sources of animal protein due to its universal acceptability, high nutritional value, and health benefits (El Sabry et al., 2023). Global meat production doubled from 1980 to 2004 and it is expected to double again between 2000 and 2050 (FAO, 2005; Steinfeld et al., 2006). This rapid expansion of the global meat production poses pressure on water resources, as livestock raising is an extremely water-intensive agricultural activity. Approximately one-third of all water used in agricultural production worldwide is used for animal production (El Sabry et al., 2023). Water is a necessary nutrient for poultry because it helps with several physiological activities, such as digestion and nutrient absorption. It plays an essential role in every aspect of metabolism and is important in the regulation of the bird's body temperature. Water constitutes about 70 to 80% of lean body mass by weight in birds (Salas et al., 2012). It is the major component of the cell as well as the extracellular environment and contributes to the regulation of cellular homeostasis (McCreery, 2015). It has been shown that normal water consumption for chickens ranges from 1.6 to 2.0 times that of feed intake (Fairchild and Ritz, 2009). This will increase greatly during extremely high temperatures. Under optimal conditions, a 2.3 kg broiler will consume about 8.2 kg of water, compared to approximately 4.6 kg of feed during its lifetime (Lacy, 2002).

The broiler's water intake is directly related to a variety of factors, including water quality (Barton, 1996). The quality of water supplied to broiler birds can significantly influence their health, productivity, and overall well-being (Manning et al., 2007). Factors such as purity, mineral content, and microbial contamination, which can significantly influence the productive and physiological parameters of broiler chickens vary depending on the source of water given to birds. Various water sources such as tap water, well water, surface water, or treated water can have diverse effects on broiler bird's physiology and performance (Kalita et al., 2021). Understanding these effects is essential for optimizing broiler production systems, and in helping farmers make informed decisions, especially on the selection of water source and on water treatment. Several studies have investigated the effects of different water sources on broiler performance. A research by Koelkebeck et al. (1999) demonstrated that the water quality of well and treated water differed significantly in their effect on bird performance. Additionally, water quality has been linked to carcass characteristics. Mir et al. (2017) suggested that variations in water composition can affect meat quality attributes such as tenderness and juiciness. Filazi et al. (2017) reported that contaminants in water may contribute to irregularities in muscle development, hence affecting the market value of broiler products. The consequences of highly contaminated water can have repercussions on both growth and reproduction (Fairchild and Ruiz, 2009). Nutrient utilization may be affected by high concentrations of minerals or contaminants. High levels of nutritional salt have been shown to increase water consumption with varying influences on feed consumption (Darden and Markes, 1985). Minias (2015) stated that changes in blood parameters, such as red blood cell count, haemoglobin concentration, and white blood cell count can be an indicator of the physiological health of broiler birds.

Over the years, various research on drinking water quality, which showed different effects on poultry performance at elevated levels of some minerals have been conducted (Koelkebeck, 2012). Poultry farmers in Ghana and other parts of the world use different sources of drinking water for poultry production without regular laboratory analysis to ensure the quality of these water sources, and their effects on the performance poultry. This study seeks to find out the effect of different sources of drinking water on the growth performance, carcass characteristics, and haematological indices of broilers.

MATERIALS AND METHODS

Experimental site and duration

The experiment was conducted at the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The study area is located within the semi -deciduous humid forest zone of Ghana with latitude 06° 41 N and longitude 01°33 W and altitude 261.4 mm above the mean sea level. This zone is characterized by a bimodal rainfall pattern with an average annual rainfall of 1,300 mm. The relative humidity varied from 83.3% in the early morning to 57.6% in the afternoon. The experiment lasted for six weeks.

Experimental birds and design

A total of 192 Ross 308 broiler day-old chicks (DOCs) were used for the study. The birds were randomly assigned to their pens in a completely randomized design (CRD). There were three treatments and four replicates per treatment. Each replicate consisted of 16 birds, making a total of 64 birds per treatment.

Experimental treatments

Three different sources of water were used for this study; two boreholes at the Poultry Section of the Department of Animal Science, designated as borehole 1 and borehole 2, and a tap water at the Faculty of Renewable Natural Resources (FRNR), KNUST.

Samples of the water were taken to the Soil Chemistry Laboratory at the Faculty of Agriculture, KNUST, to test for the composition of heavy metals such as Lead (Pb), Arsenic (As), Cadmium (Cd) Nickle (Ni), Zinc (Zn), Copper (Cu), Chromium (Cr), Mercury (Mg), Iron (Fe), Nickel (Ni) and Selenium (Se). Samples were also taken to the Microbiology Laboratory of the Veterinary Services Directorate at Amakom, Kumasi and analyzed for the presence of microorganisms such as bacteria, viruses, and protozoa, but no pathogenic microbes were recorded.

The birds were assigned to these three sources of water, with treatment one (T1) as the water from borehole 1, treatment two (T2) as the water from borehole 2, and treatment three (T3) as the tap water from the FRNR.

Management of birds

The birds were housed in 12 slatted floor pens. The birds were vaccinated against Newcastle and Gumboro diseases. Vaccination of birds was carefully carried out according to a well-planned programme and the doses were according to the manufacturer's specifications. Prophylactic measures were put in place to pre-

Table 1: Calculated nutrient composition of starter diet fed to the broiler chicks within the first two weeks

Nutrients	Quantity
ME (kcal/kg)	3,150
Crude protein	22.00%
Crude fat	7.50%
Crude fiber	2.50%
Lysine	1.30%
Methionine	0.60%
Methionine + cystine	0.95%
Calcium	0.95%
Sodium	0.20%
Phosphorus	0.65%

ME = Metabolizable Energy,
kcal = kilo calories,
kg = kilogram

Table 1: Calculated nutrient composition of finisher diet fed to broilers within the experimental period (weeks 3-6)

Nutrients	Quantity
Crude protein	20 %
Crude Fat	5%
ME (kcal/kg)	3000
Sodium	0.18%
Calcium	0.9%
Phosphorus	0.4%
Methionine	0.45%
Lysine	0.9%
Methionine + cystine	0.8%
Mould inhibitors	Added
Enzymes	Added
Salt	Added

ME = Metabolizable Energy,
kcal = kilo calories,
kg = kilogram

vent any outbreak of diseases. The birds were given a measured amount of conventional feed prepared based on locally available ingredients throughout the study. The nutrient composition of the diets are shown in Tables 1 and 2.

Parameters measured

Feed intake, weight gain, feed conversion ratio, and water intake were measured every week throughout the experiment. Carcass parameters such as live weight before slaughter, bled weight, defeathered weight, dressed weight, head weight, neck weight, the weight of wings and shank weight; and weights of internal organs such as heart, liver, gizzard, intestines and spleen were measured at the end of the study. The abdominal fat was weighed. Hematological indices (full blood count) were also analyzed.

Statistical analysis

Data generated were subjected to a one-way analysis of variance (ANOVA) using the General Linear Model with Minitab Version 18 (2019) with source of drinking water as the only source of variation. Differences between treatment means were separated using Tukey's studentized ranged test. Significant differences between treatment means were set at $p<0.05$.

RESULTS AND DISCUSSION

Heavy metals' concentration

There were variations between the values recorded for the heavy metals from the various water sources. The concentration of Arsenic was however similar for all the water sources. For most of the heavy metals, the concentration was lower than the recommended concentration by the WHO, except for the concentration of Arsenic which was similar (Table 3, not statistically analyzed). The results on heavy metal concentration indicate that the three water sources used for the study were wholesome for broiler consumption based on the heavy metal levels.

Growth performance

For all growth performance measured, there was no effect ($p>0.05$) across all treatments, however, the birds on borehole 1 had the highest values for most of the measured growth parameters, while those on borehole 2 had the lowest values (Table 4). In contrast, Kalita et al. (2021) and Manwar et al. (2012) reported numerically higher water intake for treated water as compared to untreated bore well water. In a similar study, Abbas et al. (2010) reported that water consumption was not affected ($p>0.05$) by different sources of water.

In this present study, water from different sources did not affect the final body weight and the total weight gain of the broiler birds. This corroborates the findings of Asaniyan et al. (2012) who reported that water from different sources had no effect on most growth parameters. However, they reported that weight gain was affected ($p<0.05$), with birds on treated wa-

Table 3: Heavy metals' concentration in the different sources of water employed in the study, alongside WHO's recommended concentration levels of the heavy metals

Composition of heavy metals (mg/L)	T1	T2	T3	Max. WHO recommendation
As	0.011	0.0124	0.0123	0.01
Cd	0.002	0.002	0.002	0.003
Hg	0.001	0.0009	0.0008	0.006
Pb	0.001	0.0007	0.0008	0.01
Zn	0.254	0.341	0.395	Not recommended
Ni	0.003	0.003	0.004	0.07
Cu	0.410	0.48	0.051	2.00

World Health Organization (2020)

Table 4: Effect of different sources of drinking water on growth performance of broilers

Parameters (g)	T1	T2	T3	p-values	SEM
Av Initial Weight (DOC)	37.5	37.5	37.5	0.865	0.209
Av Total Feed Intake	4919	4510	4690	0.154	0.153
Av Total Water Intake	7900	6530	6820	0.060	0.422
Feed and Water intake ratio (FI:WI)	1.61[a]	1.45[b]	1.45[b]	0.002	0.025
Av Final Weight	2120	2120	2120	0.998	0.792
Av. Total Weight Gain	2080	2080	2080	0.998	0.058
FCR (FI/WG)	2.37	2.17	2.25	0.093	0.063
Mortality (%)	12.00[a]	2.00[b]	4.00[ab]	-0.0368	1.6330

[1]DOC – Day-old chick; FCR – Feed conversion ratio; FI – Feed intake; WG – Weight gain; WI – Water intake;
[2]SEM – Standard Error of the Mean; p-values – Probability values

ter having the highest weight gain. They stated that the higher weight gain could be due to the higher quality of the treated water as reported in a study by Quiroz (2008). Other authors like Ibitoye at al. (2013) and Folorunsho et al. (2012) also reported no effect (p>0.05) on the growth performance of broiler birds when different sources of water (untreated vs treated) were given to broilers, Ibitoye et al. (2013) reported higher weight gain in the treated water group, and explained that this could be due to the different concentrations of minerals and other water qualities, as indicated by Saidy et al. (2015) in a similar study. In addition, Das (2013) in his study on different sources of drinking water attributed an increase in weight gain to the addition of an acidifier and sanitizer, which leads to an improvement in the quality of water, a reduction in pH, and a further reduction in pathogenic growth in the gastrointestinal tract of poultry.

Mortalities mostly occurred on the first day of the experiment and this could be attributed to the stress experienced by the DOCs, which agrees with the findings of Vecerek et al. (2016) who recorded higher mortalities during the first week of the arrival of DOCs. The mortalities could also be due to other physiological factors which manifested when the birds were exposed to the new environment (Leinonen et al., 2014). The other mortalities that were recorded after the first day of the experiment were recorded from a replicate in T1. This could most likely be due to the poor lighting system which resulted from some technical problems as the mortalities ceased once

Carcass traits

There were similarities between measured carcass parameters across the three treatments. However, there was an effect (p<0.05) on the neck weight. Birds given tap water recorded the highest neck weight as compared to those given waters from boreholes 1 and 2 (Table 5). This is in line with the findings of Asaniyan et al. (2012) who reported that chemicals such as cadmium and lead in treated water cause significant (p<0.05) effects on the neck weight of broiler birds. Ibitoye et al. (2013) in contrast reported no effect of different water sources (p>0.05) on the neck weight and all other carcass characteristics.

Internal organ components and Abdominal Fat

All measured internal organ components showed similarities across all three treatments (p>0.05). The abdominal fat values were higher in broilers under the two borehole waters compared to those under the tap water (p<0.05) (Table 6).

Hematological characteristics

The treatments had no significant effect (p>0.05) on white blood cell (WBC), red blood cell (RBC), hemoglobin (HGB), hematocrit (HCT),

Table 5: Effect of the different sources of drinking water on the carcass characteristics of broilers

Carcass parameters	T1	T2	T3	p-value	SEM
Live weight (kg)	2.11	2.14	2.05	0.165	0.054
Bled weight (kg)	2.01	2.02	1.99	0.908	0.049
Defeathered weight (kg)	1.85	1.90	1.92	0.431	0.061
Dressed weight (kg)	1.41	1.41	1.42	0.981	0.043
Breast weight (g)	0.46	0.43	0.46	0.684	0.042
Thigh weight (g)	0.42	0.42	0.41	0.694	0.022
Head weight (g)	0.05	0.05	0.04	0.051	0.002
Neck (g)	0.11^{b}	0.11^{b}	0.42^{a}	0.031	0.146
Shank weight (g)	0.09	0.09	0.08	0.188	0.007
Wings weight (g)	0.21	0.21	0.19	0.494	0.013

^{a,b}Mean values in the same row with different superscripts are different at $p<0.05$; SEM – Standard Error of the Mean; P-values – Probability values

Table 6: Effects of different sources of water on the internal organs and abdominal fat of broilers

Parameters (g)	T1	T2	T3	p-value	SEM
Liver	0.05	0.05	0.05	0.965	0.004
Heart	0.01	0.01	0.01	0.192	0.0008
Full Gizzard	0.06	0.06	0.06	0.938	0.006
Empty Gizzard	0.04	0.04	0.04	0.804	0.003
Full Intestine	0.10	0.11	0.10	0.394	0.009
Empty Intestine	0.08	0.08	0.08	0.745	0.004
Spleen	0.004	0.003	0.003	0.625	0.0008
Abdominal fat	0.03^{a}	0.03^{a}	0.02^{b}	0.026	0.006

mean corpuscular hemoglobin concentration (MCHC), mean corpuscular concentration (MCH) and platelet (PLT). However, there was a significant effect ($p<0.05$) of water source on mean corpuscular volume (MCV). The highest MCV was recorded in broiler birds given tap water while the lowest was recorded in broilers given water from borehole 1. Alagbe et al. (2016) reported that heavy metals had a significant effect on WBC, RBC HGB, MCH, MCHC, HCT, and PLT, which is in contrast with the findings of this study. This could be because of the higher quantities of heavy metals recorded in their study.

CONCLUSIONS

It is concluded from the study that sources of drinking water for broilers within the KNUST research area in Ghana, from boreholes or tap water have no adverse effect on the growth performance, carcass and hematological characteristics of the broiler chickens. However, broilers on tap water recorded higher values for mean corpuscular volume in the blood and neck weight and also had lower abdominal fat, which need to be investigated further.

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REFERENCES

Abbas, T., Elzubeir, E. and Arabbi, O. (2008). Drinking Water Quality and its Effects on Broiler Chicks Performance During Winter Season. International Journal of Poultry Science, 7: 10.

Asaniyan, E. K., Adene, I. C. and Adekunle, S. A. (2012). Effect of drinking water sources on performance and carcass indices of broiler chickens. Nigerian Journal of Animal Production, 39: 46-53.

Alagbe, J. O. (2016). Effect of Heavy Metals Contamination on Performance and Blood Profile of Broiler Chicks Fed Corn-Soya Meal Diet. Internatioal Journal of Advanced

Table 7: Effects of the drinking water sources on the hematological characteristics of broilers

Parameters	T1	T2	T3	p-values	SEM
WBC (10^3/UL)	183	208	194	0.372	13.8
RBC (10/UL)	2.82	0.35	1.48	0.346	1.32
HGB (g/dL)	9.83	9.65	9.03	0.725	0.842
HCT (%)	35.1	35	33.5	0.825	2.33
MCV (FL)	124.5^b	129^b	134^a	0.012	1.97
MCH (Pg)	34.9	35.2	36.1	0.476	0.776
MCHC(g/dL)	28	27.3	26.9	0.540	0.806
PLT (10^3/UL)	9.50	53.0	21.8	0.419	26.4

^{a,b}Mean values in the same row with different superscripts are different at ($p<0.05$);
SEM – Standard Error of the Mean; P-values – Probability values

Biological Research, IJABR, 6 (4): 538-542.

Das, M. (2013) Effect of acidifier and sanitizer treated drinking water on the performance of broiler chicken. M.V.Sc. Thesis, College of Veterinary Science, Assam Agricultural University, Khaqnapara, Guwahati, Assam.

El Sabry. M. I., Romeih, Z. U., Stino, F. K., Khosht, A. R. and Aggrey, S. E. (2023). Water scarcity can be a critical limitation for the poultry industry. Tropical Animal Health and Production, 55(3): 215.

Fairchild, B. D. and Ritz, C. W. (2009). Poultry drinking water primer. https://extension.uga.edu/publications/detail.html?number=B1301&title=poultry-drinking-water-primer

FAO (2005). Livestock policy brief 02. Rome: Food and Agriculture Organization. A0261 e.pdf (fao.org). https://www.fao.org/3/a02-61e/a0261e.pdf

Filazi, A., Yurdakok-Dikmen, B., Kuzukiran, O. and Sireli, U. T. (2017). Chemical Contaminants in Poultry Meat and Products. InTech. doi: 10.5772/64893

Folorunsho, O. R., Laseinde, E. A. O. and Onibi, G. E. (2012). Performance, haematology and carcass characteristics of broiler chickens given water from different sources. Nigerian Journal of Animal Production, 39 (1): 104-113.

Ibitoye, E. B., Dabai, Y. U. and Mudi, L. (2013). Evaluation of different drinking water sources in Sokoto North-West Nigeria on performance, carcass traits and haematology of broiler chickens. Veterinary World, 6: 879-883.

Kalita, S., Mahanta, J. D., Sapcota, D., Laskar, S., Borah, M. and Deka, P. (2021). Effect of different sources of drinking water on the performance of commercial broiler chicken. The Pharma Innovation Journal, SP-10(8): 67-69.

Koelkebeck, K. (2012). Drinking Water Composition and Poultry Performance. University of Minnesota. Minnesota Extension Service. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/204342.

Koelkebeck, K. W., McKee, J. S., Harrison, P. C., Parsons, C. M. and Zimmerman, R. A. (1999). Performance of laying hens provided water from two sources. J. Appl. Poult. Res. 8:374-379

Lacy, M. (2002). Broiler Management. In Commercial Chicken Meat and Egg Production, Bell DB, Weaver WB (eds). Kluwer Academic Pub. Norwell, MA; 829-868

Leinonen, I., Williams, A. G. and Kyriazakis, I. (2014). The effects of welfare-enhancing system changes on the environmental impacts of broiler and egg production. Poultry Science, 93(2): 256-266.

Manning, L., Chadd, S. A. and Baines, R. N. (2007). Key health and welfare indicators for broiler production. Worlds Poult. Sci. J. 63:46-62.

Manwar, S. J., Awandkar, S. P., Munde, V. and Waskar, V. S. (2012). Effect of different sources of drinking water and commercially treated water on the performance of broiler chicken. *Indian Journal of poultry science, 47*: 60-63.

McCreery, D. H. (2015). Water Consumption Behavior in Broilers. Graduate Theses and Dissertations. Retrieved from https://scholarworks.uark.edu/etd/1301

Minias, P. (2015). The use of haemoglobin concentrations to assess physiological condition in birds: a review. Conservation physiology, 3(1), cov007. https://doi.org/10.1093/conphys/cov007

Mir, N. A., Rafiq, A., Kumar, F., Singh, V. and Shukla, V. (2017). Determinants of broiler chicken meat quality and factors affecting them: a review. *Journal of food science and technology*, *54*(10), 2997–3009. https://doi.org/10.1007/s13197-017-2789-z

Quiroz, M. (2008). Water Quality and Broiler Performance. North Carolina Broiler Supervisor's Short Course Conference. [(Accessed on 1 February 2024)]. https://www.thepoultrysite.com/articles/water-quality-and-broiler-performance

Salas, C., Ekmay, R. D., England, J., Cerrate, S. and Coon, C. N. (2012). Determination of chicken body composition measured by dual energy X-ray absorptiometry. International Journal of Poultry Science.11 (7): 462 -468.

Steinfeld, H., Gerber, P., Wassenaar, T. D., Castel, V., Rosales, M., Rosales, M. and De Haan, C. (2006). Livestock's long shadow: environmental issues and options. Food & and Agriculture Organisation, Rome. Livestock's long shadow: environmental issues and options (fao.org)

Vecerek, V., Voslarova, E., Conte, F., Vecerkova, L and Bedanova, I. (2016). Negative trends in transport-related mortality rates in broiler chickens. Asian-Australasian Journal of Animal Sciences, 29(12):1796.

Watkins, S. E., Fritts, C. A., Yan, F., Wilson, M. L and Waldroup, P. W. (2005). The interaction of sodium chloride levels in poultry drinking water and the diet of broiler chickens, Journal of Applied Poultry Research, 14:55-59.

WHO (2022). Guidelines for Drinking-Water Quality. Fourth Edition Incorporating the First and Second Addenda. https://www.who.int/publications/i/item/9789240045064