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Effect of soft and moderately hard water intake on meat quality characteristics of broiler chickens

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Target audience: Animal scientist, Animal nutritionist, Animal farmers.

Abstract

A Fifty-six (56) days experiment was conducted to evaluate the "Effect of soft and moderately hard water intake on meat quality characteristics of broiler chickens". Three hundred (300) day old broiler chickens of Hubbard breed were used. The chickens were randomly allotted to two (2) treatment groups. Group one are chickens administered soft water (SW) and group two are chickens administered moderately hard water (MHW). Each treatment had six replicates with twenty-five (25) birds per replicate. Feed and water were provided ad libitum. Data were collected on carcass cut-up parts and visceral organs, breast meat quality characteristics and breast meat proximate composition. The percentage cut-up parts and visceral organ characteristics were significantly (P<0.05) different. Breast meat quality characteristics was also significantly (P<0.05) different in cold breast meat water holding capacity. Breast meat proximate composition values were also significantly different in the ether extract. MHW can replace SW without any adverse effect on meat quality characteristics of broiler chickens.

Key words: Soft; Moderately, Hard water; Meat quality; Broiler chickens.

Description of the Problem

As the world population continues to increase, one of the major problems faced by the developing countries is that of low and quality protein intake (1). .Protein, most especially, those from animal sources is one of the essential nutrients of human diets and is greatly lacking in the diets of the .inhabitants of the developing countries (1, 2) reported that average Nigerian consumes about 6.5 g of animal protein per day as against the Food and Agricultural Organization (3) recommendation of 35 g. This shortfall can be corrected by taking into cognizance, the welfare and wellbeing of the animal in relation to its environment and water through which it derives the required nutrients from feeds.

Poultry which offers meat and egg (protein of animal origin) on account of its short gestation period, short generative interval and handy size, is expected to play a major role in this bid to provide protein of animal source (1). It is reportedly the most commonly kept livestock and over 70 % of those farmers keeping poultry are reported to be keeping chicken (4). Broiler birds have been developed with genetic potentials for a faster growth rate to attain market weight in the shortest time possible. These genetic potentials cannot be fully utilized or expressed if the right or optimal environment is not provided (5). Water is the single most critical nutrient to health and well-being (6). Good quality water is essential for livestock and poultry production. It is an essential ingredient for life, and is also involved in several physiological functions such as, digestion, absorption, enzymatic functions, nutrient transportation, and thermoregulation, lubrication of joints and organs and elimination of wastes (7). Water hardness is related to concentration of minerals, such as calcium and magnesium, dissolved in water (8). These minerals are naturally found in soil and rocks in locations with high concentration of limestone, dolomite or gypsum in the ground. Hard water is produced as minerals from these ground deposits becomes dissolved in water flowing through the earth (9). The shortfall in protein intake by inhabitants of the developing countries as against the FAO recommendation and inadequate supply of soft water by the water works, which has forced the exploration of and dependence on borehole and well water (hard water sources) by man and animals, has brought a need for this research. Hence the need to determine the effect of moderately hard water on meat quality which is the primary source of protein.

Materials and Methods

A total of three hundred broiler chicks of hubard breeds were used for the experiment. The chicks were managed under the deep liter system and divided into two groups, SW and MHW. Group SW denoted chickens administered soft water while Group MHW denoted chickens administered moderately hard water. Each group had six replicates and each replicate was randomly allotted twenty five (25) chicks. Commercial broiler starter and finisher diets from Hybrid Feeds, and water were given *ad libitum.* Newcastle disease vaccine (Lasota) and Infectious bursal disease vaccine (Gumboro) were also administered through drinking water (soft and hard water) following the recommendation of (**10**).

Meat Yield and Meat Quality Characteristics

At the end of the experiment, two broiler chickens from each replicate were randomly selected for meat yield and meat quality characteristics. The selected broiler birds were starved of feed and water for twelve (12) hours. The records of the chickens' individual weights were taken before slaughter. The broiler chickens were slaughtered, hanged by the hock head down and bled for two minutes and scalded at 55$^{\varepsilon}$C for one minute. The feathers were manually removed. Thereafter, the record of the fully dressed individual carcass weight was taken after complete evisceration. The carcasses were separated into parts (breast, back, thigh, wing and drumstick) and visceral organs (intestine, kidney, liver, gizzard, abdominal fat, lungs, spleen and heart). The weight of each body cut, and organs were taken and expressed as percentage of the live weight of each carcass. The dressing percentage and percentage of body weight in relation to the live weights of the chickens were calculated as described by (11) in the formulae below.

Dressing percentage =

$$\frac{\text{Carcass weight}}{\text{Live weight}} \times \frac{100}{1}$$

Percentage of body cut=

$$\frac{\text{weight of body cut}}{\text{Live weight}} \times \frac{100}{1}$$

Water Holding Capacity

The water holding capacity of the hot and cold breast muscle samples from each replicate were evaluated following the procedure described by (12). 10 g of fresh/hot breast muscle was taken using a sensitive weighing scale. The sample was laid between two filter papers and pressed in a screw jack to expel out the water/fluid contained in it. The sample was then removed from the filter papers and weighed again. The difference between the initial and final weights is the weight of the expelled water/fluid which is expressed as a percentage of the initial sample weight and recorded as the Hot Breast Carcass Water Holding Capacity (HBCWHC). Similarly, 10 g of the cold/refrigerated breast muscle from each replicate was taken for the evaluation of the Cold Breast Carcass Water Holding Capacity (CBCWHC) following the same procedure.

Cooking Yield and Cooking Loss

The evaluation of the cooking yield and cooking loss were carried out following the procedure described by (13). 20 g of the breast muscle from selected chickens of each replicate were taken for boiling. The boiling was done by placing each meat sample in a glass container, containing 20 ml water. The water bath was then preheated for five (5) minutes before the glass containers were placed in. After placing the glass containers in the water bath, broiling was done up to 75^{o} C measured by skewer thermometer for thirty (30) minutes. The samples were then removed from the water bath and allowed to cool at room temperature, mopped off of excess fluid using a serviette paper and the weight of each sample was taken and recorded. The cooking loss and cooking yield were then calculated using the formulae below.

Cooking Loss = Initial meat weight – cooked meat weight

Cooking yield (%) =

$$\frac{\text{Cooked meat weight}}{\text{Initial meat weight}} \times \frac{100}{1}$$

pH

The pH of the breast muscle was measured using a pH meter. This was done immediately after dressing the chickens. An incision of the breast muscle was made using a kitchen knife and the electrode was inserted into the incised point and readings from the pH meter screen was read and recorded.

Proximate Composition of Broiler Breast Meat

A sample of the breast muscle was taken from each chicken to determine the proximate composition. Parameters measured include moisture content, crude protein, ash and ether extract as described by (14).

Data Analysis

All data obtained from the experiment

were subjected to Independent Sample T Test statistical analysis, using Statistical Analysis System (15).

Results

Table 1 shows the physic-chemical properties of the SW from Niger State water works Chanchaga, Minna and the MHWfrom the well at Federal University of Technology Minna commercial farm, Garatu. All in Niger State, Nigeria. The proximate composition of the starter and finisher diets are shown in Table 2. The values obtained for crude protein, crude fibre, ether extract, ash and nitrogen free extract are within the recommended range of nutrients for broiler chicken production.

Table 1 Physicochemical properties of soft and moderately hard water

Physicochemical Properties	Soft Water	Moderately Hard Water	NSDWQ Maximum Permitted Levels
Odour	Odourless	Odourless	Unobjectionable
Turbidity (NTU)	3.03	3.05	5.00
Colour (TCU)	8.00	13.00	15.00
pH	7.59	7.33	6.5-8.5
Total Dissolved Solid (mg/L)	70.00	190.00	500
Dissolved Oxygen (mg/L)	8.0	6.94	-
Temperature (°C)	26.20	22.90	Ambient
Total Hardness (mg/L)	12.00	114.00	150.00
Chloride (mg/L)	8.00	18.40	250.00
Total Alkalinity (mg/L)	14.00	32.00	-
Nitrate (mg/L)	3.60	10.60	50.00
Iron (mg/L)	0.07	0.11	0.30
Sodium (mg/L)	18.00	13.00	200.00
Potassium (mg/L)	11.00	7.00	-
Calcium (mg/L)	14.40	34.40	-
Magnesium (mg/L)	5.77	6.83	20.00
Bicarbonate (mg/L)	14.00	21.00	-
Fluoride (mg/L)	0.14	0.10	1.50
Sulphate (mg/L)	12.00	14.00	100.00
Nitrite (mg/L)	0.03	0.13	0.20
Zinc (mg/L)	0.21	0.89	3.00
Copper (mg/L)	0.02	0.12	1.00
Chromium (mg/L)	0.01	0.03	0.05
Arsenic (mg/L)	0	0	0.01

NTU: Nephelometric Turbidity Units. TCU: True Colour Units

Table 2 Proximate composition of broiler starter and finisher diets

Parameters (%)	Starter diet	Finisher diet
Dry matter	93.04	93.00
Ash	3.95	4.20
Crude Protein	22.35	20.67
Crude Fibre	4.15	4.65
Ether extract	11.25	11.60
Nitrogen Free Extract	51.45	51.89

Table 3 Carcass cut-up parts characteristics of broiler chickens administered soft and moderately hard water

Treatment	Mean	T.Test Value
SW	2325.00	-1.01
MHW	2450.00	
SW	1885.41	-0.65
MHW	1956.34	
SW	81.11	1.46
MHW	79.68	
SW	12.10	1.09
MHW	11.69	
SW	10.45	1.64
MHW	9.97	
SW	8.47	1.16
MHW	8.08	
SW	20.85	1.53
MHW	19.81	
SW	10.90[a]	2.84
MHW	10.20[b]	

ab: means in the same column with different superscripts are significantly different (P<0.05)
S: Soft water MHW: Moderately hard water Wt.: Weight

The carcass cut-up parts characteristics of broiler chickens administered SW and MHW is shown in Table 3. There were no significant (P>0.05) difference in most of the parameters measured among the treatment means. Only the result of the Back showed significant (P<0.05) difference. Broiler chickens administered SW had better back percentage compared to those given MHW.

The visceral organ characteristics of broiler chickens administered SW and MHW shown (Table 4). The result revealed no significant (P>0.05) differences in all the parameters measured. However, significant (P>0.05) difference was observed in the lungs. Broiler chickens administered MHW had lower lungs percentage compared to those given SW. The breast meat quality characteristics of broiler chickens administered SW and MHW shown (Table 5). The result showed significant (P<0.05) difference in the percentage of cold breast meat water holding capacity, with chickens administered MHW recording higher value than those administered SW. However, no significant (P>0.05) difference was observed in other parameters measured. The proximate composition of breast meat of broiler chickens administered SW and MHW is shown in Table 6. Significant (P>0.05) difference was only observed in the ether extract, with chickens administered moderately hard water recording lower mean value as compared with chickens administered soft water.

Discussion

The physicochemical properties of the SW and MHW are within the range permitted by the Standard Organisation of Nigeria under the Nigerian Standards for Water Drinking Quality Manual (16). The value of total hardness (12.00 mg/l) in the soft water shows it falls within the class of soft water as classified by (17). Also, the value of total hardness (114 mg/l) of the hard water recorded falls within the range of moderate hardness as reported by (17). The values of calcium and magnesium concentrations in the

Table 4 Visceral organs characteristics of broiler chickens administered soft and moderately hard water

Parameter	Treatment	Mean	T.Test Value	Standard Deviation
Intestinal Lt. (cm)	SW	173.99	-1.53	25.71
	MHW	190.00		25.50
Intestinal Wt. (g)	SW	4.47	0.70	1.81
	MHW	4.07		0.79
Kidney (%)	SW	0.04	0.49	0.05
	MHW	0.03		0.01
Liver (%)	SW	2.10	0.63	0.43
	MHW	1.99		0.37
Gizzard (%)	SW	2.05	0.47	0.20
	MHW	1.99		0.37
Abdominal Fat (%)	SW	2.27	1.15	0.80
	MHW	1.94		0.57
Lungs (%)	SW	0.73[a]	2.33	0.12
	MHW	0.62[b]		0.11
Spleen (%)	SW	0.62	1.60	0.18
	MHW	0.54		0.07
Heart (%)	SW	0.52	-0.41	0.08
	MHW	0.54		0.08

ab: means in the same column with different superscripts are significantly different ($P<0.05$)
S: Soft water MH: Moderately hard water Lt.: Length Wt.: Weight

Table 5 Breast meat quality characteristics of broiler chickens administered soft and moderately hard water

Parameter	**Treatment**	**Mean**	**T.Test Value**	**Standard Deviation**
HBMWHC (%)	SW	19.28	0.88	1.74
	MHW	17.78		5.67
CBMWHC (%)	SW	14.59[b]	-2.11	6.93
	MHW	20.45[a]		6.67
Cooking Loss (g)	SW	4.01	-1.38	0.99
	MHW	4.56		0.98
Cooking Yield (%)	SW	79.96	1.38	4.95
	MHW	77.19		4.89
pH	SW	6.24	0.17	0.38
	MHW	6.22		0.17

ab: means in the same column with different superscripts are significantly different ($P<0.05$)
S: Soft water MH: Moderately hard water Wt.: Weight
HBMWHC: Hot Breast Meat Water Holding Capacity
CBMWHC: Cold Breast Meat Water Holding Capacity

Table 6 Proximate composition of breast meat of broiler chickens administered soft and moderately hard water

Parameter	Treatment	Mean	T.Test Value	Standard Deviation
Dry Matter (%)	SW	31.79	-1.88	1.26
	MHW	31.05		0.52
Ash (%)	SW	1.05	1.82	0.15
	MHW	0.92		0.19
CP (%)	SW	22.51	-0.73	1.27
	MHW	22.94		1.57
CF (%)	SW	0.73	2.00	0.13
	MHW	0.63		0.14
Ether Extract (%)	SW	2.98[a]	4.51	0.33
	MHW	1.87[b]		0.78
Nitrogen Free Extract (%)	SW	4.52	-0.31	1.44
	MHW	4.70		1.44

ab: means in the same column with different superscript are significantly different ($P<0.05$)
S: Soft water MH: Moderately hard water Wt.: Weight CP: Crude Protein

MHW also fall within the range reported by (18). The proximate compositions of the commercial starter and finisher feeds are within the range of requirements and recommendations given by (19, 20). The carcass yield and characteristics of cut-up parts and visceral organs variation in the back and lungs could largely be due to the influence of water type on which the birds were placed. However, all values obtained are within the range recorded by (21) when they evaluated the Growth response, meat yield and carcass characteristics of broiler chickens fed Beniseed (*Sesamum indicum)* and Drumstick (*Moringa oleifera)* leaves as sources of lysine

The significant ($P<0.05$) differences shown with regard to the breast meat quality characteristics is an indication that MHW has influence on the carcass quality of broiler chickens. This disagrees with the report of (22) who reported that calcium, magnesium, iron and copper decrease the WHC. Also, the 20.45 % water holding capacity of the cold breast meat recorded from broilers offered MHW is similar with the report of (23). The author reported that water holding capacity of broiler meat at the age of 6 and 7 weeks was 22.19 % to 28.54 % respectively. However, the pH values obtained for both chickens offered SW (6.24) and MHW (6.22) are within the range reported by (24). The author reported 6.31 as average pH of the breast meat of broiler chicken.

The proximate composition of the breast meat showed an influence of MHW on ether extract and as such, maintaining a lower mean value than those of the birds offered SW. This agrees with (25, 26, 27, 28). They all reported chemical components values of breast muscles of over 22.50 % for total proteins and less than 3.00 % for lipid content. However, values recorded fall within the range reported by (29) in their experiment of chemical composition, fatty acid profile and colour of broiler meat as affected by organic and conventional rearing systems.

Summary and Conclusion

It was concluded from this research that MHW has no adverse effect on the meat yield, visceral organ characteristics and meat quality characteristics, except in the cold meat water holding capacity. MHW can conveniently substitute SW and hence farmers should be encouraged in its use in order to sustain and boost production.

References

1 Oladoja, M.A., & Olusanya, T.P. (2009). Impact of Private Formulation and Production as a Tool for Poverty Alleviation among Poultry Farmers in Ogun State, Nigeria. *International Journal of Poultry Science.* 8 (10), 1006-1010.

2 Odoemelam,V.U., Ahamefule, F.O.,Ahiwe,E.U., Ekwe,C.C. and Obi,J.I (2014). Carcass Yield, Organ Characteristics and Economics of West African Dwarf Bucks Fed *Panicum maximum* Supplemented Concentrate Containing Bambara Nut (*Vigna subterranean*) Meal. *Nigerian*

Journal of Agriculture, Food and Environment. 10(4):18-24

3 F.A.O. (1985). Food and Agricultural Organisation Production Year Book. Rome, Italy.

4 Udoh, E. I & Etim, N. A. (2008). Determinants of Technical Efficiency in Poultry Production. The Case of Urban Broiler Farms in Calabar, Nigeria. In: Adeyemi, O. A., Ogungbesan, A. M., Dada, A. O., Eniolorunda, O. O., Awojobi, H. A., Oke, D. B & Agunbiade, J. A (Eds). *Proceedings of 33rd Annual Conference of the Nigeria Society for Animal Production. pp:320.*

5 Adeyemo, G.O. (2013). Growth Performance of Broiler Chickens Fed Fossil Shell Growth Promoter. *Journal of Food and Nutrition Sciences. .* 4 (1), 16-19

6 Jeff, B. (2013).TiredƐ AgedƐ Not Losing WeightƐ Add This 1 Nutrient and see a Huge Change in: The Premier Muscle and Fitness, Nutrition and Health Resource Portal. http://*www.musclemagfitness.com*

7 Abdullahi, A.M. (2011). Impact of different Locations Water Quality in Basra Province on the Performance Physiological Changes in Chicks. *Pakistan Journal of Nutrition,* 10 (1), 6-94

8 Kovach, S.M. (2007). Improve Your Cleaning Process. How Water Hardness Affects Cleaning. *Mater Management HealthCare.* 16, 52-53.

9 Arthur, H.J & Roland, H. (2009). Role of water hardness in rinising bacteria from the skin of processed broiler chicken. *International Journal of Poultry Science* 8 (2), 112-115.

10 Cargill, P.W., Joey, J., & Merial Avian Business Unit UK. (2007). Vaccine Administration to Poultry Flocks. Retrieved from http://www.thepoultrysite.com/articles/742/vaccine-administration-to-poultry-flocks/.

11 Aduku, A.O. & Olukosi, J.O. (1990). *Rabbit management in the tropics*. Abuja, Nigeria: Living Book Series G.U. Publications.

12 Kauffman, R.G., Cassens, R.G., Scherer, A., & Meeker, D.L. (1992). Variation in Pork Quality; History, Definition, Extent, Resolution. *A National Pork Producers Council Publication Washington D.C. USA.*

13 Bethany A.S., Juhi R.W., Marybeth D., Juliette C.H., Kristine Y.P., Janet M.R., & Joanne M.H. (2012). USDA Table of Cooking Yields for Meat and Poultry. Nutrient Data Laboratory Beltsville Human Nutrition Research Center Agricultural Research Service U.S. Department of Agriculture. 5.

14 Association of Analytical Chemists. (1990). *Official methods of analysis* (15th ed.). Arlington,

Virginia, U.S.A.

15 SAS (2002). Stastical Analysis System Institutes. User's guide. SAS Institute Inc. Cary, N. C.

16 Standard Organization of Nigeria (2007). Nigeria standards for water quality manual.

17 Annelies, J. H., & Lemley, A. T. (2005). Hard water quality program, College of Human Ecology, Cornell University. Water Bulletin.

18 NRC. (1977). Drinking water and health. The National Academies Press. 1, 342-355. Washington, DC, National Academy of Sciences.

19 Aduku, A. O and Olukosi, R. D. (2000).Animal Products Processing and Handling in the tropics. Abuja NigeriaLiving Book series G.U. Publications pp 46.

20 Kirk, C. K. (2015). Nutrtional Requirements of Poultry. The Merck Veterinary Manual.

21 Jiya, E. Z., Ayanwale, B. A., Ibrahim, A. B., & Ahmed, H. (2014). Growth Response, Meat Yield and Carcass Characteristics of Broilers Fed Beniseed (Sesamum indicum) and Drumstick (Moringa oleifera) Leaves as Sources of Lysine. American Journal of Experimental Agriculture, 4(10), 1178-1185.

22 Marco, A. T., Pedro, E. D. F., & Carmen, J. C. C. (2004). Mechanically separated meat of broiler breeder and white layer spent hens. Scientia Agricola. 61 (2), 234-239.

23 Soeparno, A. (2005). Meat Science and Technology. Gadjah Mada University-Press, Yogyakarta, Indonesia.

24 Suradi, K. (2008). Change of Physical Character of Broiler Chicken Meat Post Mortem During Room Temperature Storage. Retrieved from http://pustaka.unpad.ac.id/wpcontent/uploads/2009/11/perubahan_sifat_fisik_daging_yam_broilerspot-mortem.pdf

25 Marcu, A., & Vacaru-Opriş, I. (2009). The influence of feed protein and energy level on meat chemical composition from different anatomical regions at Cobb 500 hybrid, Scientific Papers Animal Science and Biotechnology Timisoara. 42 (1), 147-150.

26 Marcu, A., Vacaru-Opriş, I., Marcu, A., Nichita, I., Nicula, M., Dronca, D., & Kelciov, B. (2011). Influence of energy and protein level of the feed on carcass characteristics and meat quality of hybrids Ross 308 and Arbor Acres. Scientific Papers Veterinary Medicine-Timisoara. 44(2), 220-230.

27 Marcu, A., Vacaru-Opriş, I., Marcu, A., Nicula, M., Dronca, D., & Kelciov, B. (2012). The influence of feed energy and protein level on meat quality at Hubbard F15 broiler chickens, Scientific Papers Animal Science and Biotechnology. 45 (2), 432-439.

28 Suchy, P., Jelínek, P., Straková, E., & Hucl, J. (2002). Chemical composition of muscles of

hybrid-broiler chickens during prolonged feeding, Czech Journal of Animal Science, 47 (12), 511-518.

29 Kucukyilmaz, K., Bozkurt, M., Catli, A. U., Herken, E. N., Cinar, M., & Bintas, E. (2012). Chemical composition, fatty acid profile and colour of broiler meat as affected by organic and conventional rearing systems. South African Journal of Animal Science, (4), 42.