doi:10.1017/S0043933909000373

The effect of saline drinking water on broilers and laying hens performance

T.E.E. ABBAS[1]*, E.A. EL-ZUBEIR[2] and O.H. ARABBI[3]

[1]Department of Poultry Production and Technology, Faculty of Agricultural Technology and Fish Science, University of Elneelein, PO Box 12702, Khartoum, Sudan; [2]Department of Poultry Science, Faculty of Animal Production, University of Khartoum, PO Box 32, Khartoum North, Sudan; [3]Department of Animal Health, Faculty Animal Production, University of Gezira, Medani, Sudan
***Corresponding author: talhabbs@yahoo.com**

Most nutritional studies with minerals have been carried out using dietary supplements, with little attention given to the role of those commonly found in drinking water. This is important since underground water supplies, which may contain high concentrations of dissolved salts, is a common source of drinking water for poultry in many countries. Recent evidence suggests that some minerals may exert adverse effects on the performance of growing broilers and laying hens when present in drinking water at concentrations similar to those found in other sources. Commercially farmed birds already receive a balanced diet and if they are also receiving high levels of nutrient as salt in the water in the form of sodium and chloride ions, then the performance of the birds may be negatively affected.

Keywords: drinking water; saline; layers; broilers

Introduction

Salinity is defined as the concentration of salts dissolved in water. Salinity may be due to the dominant presence of a particular salt, or to the presence of several minerals of varying concentrations (Dupriez and De Leener, 1992). Highly saline water may contain sufficient calcium, magnesium, sodium bicarbonate, chloride and sulphate ions to exert toxic effects (Cheeke, 2005). Kellems and Church (2002) reported that the tolerance of animals to dissolved salts in water depends on factors such as water requirements, species, age, physiological condition, season of the year and salt content of total diet. Generally water containing more than 1% NaCl (common salt) is generally not considered good quality, because this approximates to the maximum that cattle and sheep can tolerate without losing performance or production. Animals such as chickens and swine, will typically not tolerate this level of salt.

© World's Poultry Science Association 2009

Received for publication July 13, 2008
Accepted for publication December 12, 2008

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press

Occurrence of higher levels of sodium and chloride

Some studies have shown that wells are the primary source of water containing elevated levels of salts. Koelkebeck *et al.* (1999) found that sodium and chloride concentrations in rural well water were higher than those of the city water. Also, Abbas *et al.* (2008a) have recently reported that levels of total dissolved solids, hardness, alkalinity, calcium, magnesium, chloride and sodium in rural well water in North Africa were higher compared to the Nile water (*Table 1*).

Table 1: Chemical analysis of water obtained from different sources.

Parameters	Nile	Well
Total dissolved solids (mg\L)	104	200
Hardness (mg\L)	80	156
Alkalinity (mg\L)	90	200
Calcium (mg\L)	22.4	40
Magnesium (mg\L)	5.76	13.44
Sulphate (mg\L)	8	8
Chloride (mg\L)	8	12
Sodium (µg/ml)	13.50	23.32
Potassium (µg/ml)	1.70	3.83

(Source: Abbas *et al.*, 2008a)

Effect of saline water on laying hens performance

Balnave and Zhang (1993) found that, addition of 796 mg Na/l to the drinking water of laying hens negatively affect eggshell breaking strength, the concentration of calcium – binding protein (CaBP) and the activity of carbonic anhydrase (CA) when compared to the town water containing 10 mg Na/l. Moreng *et al.* (1992) confirmed these effects on eggshell by addition of 2 g NaCl/l to town water. Pourreza *et al.* (1994) studied the relationship of plasma calcium and phosphorus on the shell quality of laying hens receiving saline drinking water. The authors showed that offering higher level of NaCl either in the drinking water or in the feed to the laying hens decreased shell thickness and shell calcium, and increased the number of damaged eggs, but elevated level of NaCl in the drinking water was more deleterious to the eggshell.

The effects of saline drinking water on pullets at different ages were examined by Yoselewitz and Balnave (1989b), who reported that when the birds were given saline drinking water (2g NaCl/l) before sexual maturity, their subsequent eggshell quality did not show any response to the saline water. The same effect was observed when laying hens receiving saline drinking water from or after point of lay. It was also noted that birds supplied with saline drinking water at 40-week-old produced eggs with defective shells more rapidly compared to those given saline drinking water during the first few weeks of lay. The effect of saline drinking water on eggshell quality can be overcome when hens in early lay were given town water (3 mM Na and <1mM Cl) for five weeks. This response was not observed with 40-week-old hens.

Zhang *et al.* (1991) reported that supplementing the drinking water of laying hens with 2g NaCl/l induced large increases in eggshell defects with significantly (two fold) higher incidence of embryonic deaths and a significantly lower (13%) hatchability of fertile eggs. Saline water had little effect on reproductive performance of cockerels. Yoselewitz and Balnave (1989a) compared effects of sodium chloride when supplied to hens in the

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press

feed against supplementation with drinking water. The authors found that supplementing the drinking water of 50-week-old laying hens with NaCl at levels of 0.5, 1 and 2 g/l for seven weeks significantly increased eggshell defects two, three and four-fold respectively. Providing dietary NaCl at 1 or 2 g/kg in feed had little effect on eggshell quality.

Balnave *et al.* (1989) demonstrated the effect of NaCl in the drinking water (600 and 2000 mg NaCl/l) on the eggshell quality. The authors pointed out that there was a little effect of adding NaCl to the drinking water on blood acid – base balance and electrolytes, but significantly reduced carbon dioxide tension, and bicarbonate and calcium concentrations in the fluid surrounding the egg in the shell gland. Balnave and Yoselewitz (1987) observed that shell defects due to saline drinking water (600 mg NaCl/L) declined when birds were placed on normal water for five weeks, but were still 1.4–2.1 fold greater than control values.

In contrast to the above reports, Maurice (1989) conducted four experiments with up to 90-week-old hens and provided up to 1200 ppm NaCl for as long as twelve weeks without causing any decrease in shell strength measured as shell weight per unit surface area. The author speculated that this contrasting result may have been due to breed differences.

A report by Pourreza and Edriss (1994) gave mixed results from high–level administration of NaCl through feed and water to White Leghorn hens. Eggshell thickness was reduced by 2000 ppm NaCl in drinking water, but not by 1000 ppm. The 2000 ppm level was also reported to increase the incidence of defective shells; however, that same water treatment coupled with an additional 2000 ppm NaCl in the feed did not elevate defective shell percentage above control levels. Damron (1998) results concurred with those reported by Maurice (1989), which were in contrast to other literature reports, as their visually determined shell defects and egg specific gravity measurements were not adversely affected by NaCl supplementation (tap water with 9 ppm Na supplemented with 0 to 800 ppm NaCl) of the drinking water supplied to the layers. Again, these authors speculated that results may have been due to the strain of bird employed. Chen and Balnave (2001) observed that production and eggshell quality were significantly reduced at 30ºC compared with 18ºC, but were not significantly affected by saline drinking water. The authors mentioned that these result indicated Isa Brown hens were relatively insensitive to intakes of NaCl from the drinking water at concentrations of 2 g/l. Researchers also suggested that, this contrasting sensitivity may relate to the concentration of dietary NaCl used during the selection of layer genotypes.

Potential mechanisms by which saline water affect eggshell quality

There have been some proposals put forward regarding the mechanism by which saline water affects eggshell quality. Austic and Keshavarz (1988) speculated that the eggshell defects observed when laying hens given excessive NaCl is due to the effect of salt on the eggshell calcification process, and this effect was exacerbated when dietary calcium is limiting. Balnave *et al.* (1989) suggested that the defect in eggshell quality as the result of providing saline water was mainly due to reduced supply of bicarbonate, rather than to an effect of Ca availability, in the lumen of the shell gland. The reduced residence time of eggs in the shell gland may also play a role in this problem.

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press

Correction of eggshell defects caused by saline drinking water

There were some methods examined to overcome eggshell defect caused by saline water, such as replacement of saline water with town drinking water, resting hens from lay, addition of calcium carbonate to the diet and remove of NaCl from the diet. Recently simultaneous supplementation of saline drinking water with either sodium or ammonium bicarbonate was attempted which resulted in substantial reduction but not entire correction of occurrence of eggshell defect (Yoselewitz *et al.*, 1991). Balnave and Zhang (1993) provided saline drinking water containing dietary Zn sulphate, Zn–methionine or chelated Zn–EDTA (1 g/kg Zn), which resulted in significant reduction of the incidence of poor eggshell quality. Simultaneous supplementation of saline drinking water with ascorbic acid (1 g/l) was given in trials conducted by Balnave *et al.* (1991). The authors found that ascorbic acid prevented deleterious effect of saline water on eggshell quality. However ascorbic acid was not effective when administered after hens had been on saline water for several weeks.

Effect of saline water on broilers performance

Deyhim and Teeter (1995) found that drinking water supplemented with NaCl (0.067 mol/l) significantly increased weight gain and water consumption of broilers reared in thermoneutral and cycling heat stress environment, but had no effect on the plasma concentrations of Na^+, K^+, aldosterone or rectal temperatures. The results of this study indicated that broiler chickens kept in a heat stress environment are under osmotic stress and supplementing drinking water with 0.067 mol/l NaCl does not lessen this stress. Deyhim and Teeter (1991) mentioned that, at 35ºC, drinking water containing excess NaCl (0.39%) decreased venous PCO_2 and HCO_3^-, increased PO_2 but had no effect on venous pH and water consumption relative to heat–distressed control. NaCl failed to impact plasma corticosterone. The authors suggested that, to a lesser extent, NaCl reduces heat–distressed consequences by a mechanism as yet undefined.

Watkins *et al.* (2005) reported that elevated levels of Na and Cl either in the drinking water or in the diet produced significant effects on the performance of broilers. The significant interaction between dietary and water levels of these mineral on the broilers performance was also observed. The authors stated that Na and Cl in the drinking water should be considered when minerals requirements of broilers are being established, and must be adjusted accordingly.

Xiang *et al.* (2004) found that, drinking water containing 600 and 1200 mg/l Na from NaCl significantly increased the incidence of pulmonary hypertension syndrome and the right to total ventricle weight ratio (RV/TV). Shlosberg *et al.* (1998) reported that the addition of 1000 mg/l Na as NaCl to mains-derived town water significantly increased the incidence of mortality from ascites in cold–exposed broilers from days 28 to 47 of age.

Damron and Flunker (1993) performed two broilers experiments, each lasting 21 days. A 5.25% sodium hypochlorite solution was used to provide chloride levels of 0, 10, 100, or 500 ppm in the first study, and 0, 150, 200, 250, 300, 350, 400, or 450 ppm in the second study. The authors found that water consumption was reduced in the 100 ppm chloride treatments, and body weight was impaired when receiving the 300 ppm Cl treatment.

Mushtag *et al.* (2005) provided three levels of dietary sodium (0.20, 0.25 and 0.30%) and chloride (0.30, 0.40 and 0.50%) to broilers under subtropical summer conditions. Significantly dietary effect of Na^+ x Cl^- was noted for litter moisture and serum HCO_3^-.

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press

Birds fed diet containing 0.25% Na^+ and 0.30% Cl^- performed as well as those fed other diets when the cyclic temperature ranged from 32 to 39ºC.

Conclusions

Saline drinking water may negatively affect the performance of laying hens and broilers. Therefore, drinking water used for layers and broilers should be analyzed specially that of well source, because higher level of Na and Cl are expected to be found in the well water as shown in the study. Finally periodical check of water quality should be performed every 6-12 months in order to ensure water quality is not compromising poultry performance.

References

ABBAS, T.E., ELZUBEIR, E.A. and ARABBI, O.H. (2008a) Drinking water quality and its effects on productive performance and immune response of layers. *International Journal of Poultry Science* **7**: 441-444.

AUSTIC, R.E. and KESHAVARZ, K. (1988) Interaction of dietary calcium and chloride and the influence of monovalent minerals on eggshell quality. *Poultry Science* **67**: 750-759.

BALNAVE, D. and YOSELEWITZ, I. (1987) The relation between sodium chloride concentration in drinking water and egg – shell damage. *British Journal of Nutrition* **58**: 503-509.

BALNAVE, D., YOSELEWITZ, I. and DIXON, R.J. (1989) Physiological changes associated with the production of defective egg – shells by hens receiving sodium chloride in the drinking water. *British Journal of Nutrition* **61**: 35-43.

BALNAVE, D., ZHANG, D. and MORENG, R.E. (1991) Use of ascorbic acid to prevent the decline in eggshell quality observed with saline drinking water. *Poultry Science* **70**: 848-852.

BALNAVE, D. and ZHANG, D. (1993) Research note: responses of laying hens on saline drinking water to dietary supplementation with various zinc compounds. *Poultry Science* **72**: 603-606.

CHEEKE, P.R. (2005) Nutrients and toxic elements in water, in: *Applied Animal Nutrition Feeds and Feeding*, 3rd edition, pp. 290-292 (Pearson Prentice Hall, Upper Saddle River, New Jersey).

CHEN, J. and BALNAVE, D. (2001) The influence of drinking water containing sodium chloride on performance and eggshell quality of a modern, colored layer strain. *Poultry Science* **80**: 91-94.

DAMRON, B. L. (1998) Sodium chloride concentration in drinking water and eggshell quality. *Poultry Science* **77**: 1488-1491.

DAMRON, B.L. and FLUNKER, L.K. (1993) Broiler chick and laying hen tolerance to sodium hypochlorite in drinking water. *Poultry Science* **72**: 1650-1655 (Abstract).

DEYHIM, F. and TEETER, R.G. (1991) Research note: Sodium and potassium chloride drinking water supplementation effects on acid – base balance and plasma corticosterone in broilers reared in thermoneutral and heat – distressed environments. *Poultry Science* **70**: 2551-2553.

DEYHIM, F. and TEETER, R.G. (1995) Effect of heat stress and drinking water salt supplements on plasma electrolytes and aldosterone concentrations in broiler chickens. *International Journal of Biometeorology* **38**: 216-217.

DUPRIEZ, H. and DE LEENER, P. (1992) Salinity and salination of irrigated land, in: *Ways of Water: Run-off, Irrigation and Drainage (Tropical handbook)*, 1st edition, pp. 250 (Macmillan Press LTD, London and Basingstoke).

KELLEMS, R.O. and CHURCH, D.C. (2002) Nutrients: Their metabolism and feeding standards, in: *Livestock Feeds and Feeding*, 5th edition, pp. 16-19 (Prentice Hall, Upper Saddle River, New Jersey).

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. *Journal of Applied Poultry Research* **8**: 374-379.

MAURICE, D.V. (1989) Salinity of drinking water and performance of chickens. *Proceedings of the Georgia Nutrition Conference*, University of Georgia, Athens, GA, pp 140-144.

MORENG, R.E., BALNAVE, D. and ZHANG, D. (1992) Dietary zinc methionine effect on eggshell quality of hens drinking saline water. *Poultry Science* **71**: 1163 -1167.

MUSHTAG, T., SARWAR, M., NAWAZ, H., MIRZA, M.A. and AHMAD, T. (2005) Effect and interactions of dietary sodium and chloride on broiler starter performance (hatching to twenty – eight days of age) under subtropical summer conditions. *Poultry Science* **84**: 1716-1722.

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press

POURREZA, J., NILI, N. and EDRISS, M.A. (1994) Relationship of plasma calcium and phosphorous to the shell quality of laying hens receiving saline drinking water. *British Poultry Science* **35**: 755-762

SHLOSBERG, A., BELLAICHE, M., BERMAN, E., BEN DAVID, A. and DEEB, N. (1998) Comparative effects of added sodium chloride, ammonium chloride or potassium bicarbonate in the drinking water of broilers, and feed restriction on the development of the ascites syndrome. *Poultry Science* **77**: 1287-1296.

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.

XIANG, R.P., SUN, W.D., ZHANG, K.C., LI, J.C., WANG, J.Y. and WANG, X.L. (2004) Sodium chloride induced acute and chronic pulmonary hypertension syndrome in broiler chickens. *Poultry Science* **83**: 732-736.

YOSELEWITZ, I. and BALNAVE, D. (1989a) Responses in eggshell quality to sodium chloride supplementation of the diet and/or drinking water. *British Poultry Science* **30**: 273-281.

YOSELEWITZ, I. and BALNAVE, D. (1989b) Eggshell quality responses of pullets given saline drinking water at different ages. *British Poultry Science* **30**: 715-718.

YOSELEWITZ, I., ZHANG, D. and BALNAVE, D. (1991) The effect on egg shell quality of supplementing saline drinking water with sodium or ammonium bicarbonate. *Australian Journal of Agricultural Research* **41**: 1187-1192.

ZHANG, D., MORENG, R.E. and BALNAVE, D. (1991) Reproductive performance of artificially inseminated hens receiving saline drinking water. *Poultry Science* **70**: 776-779.

https://doi.org/10.1017/S0043933909000373 Published online by Cambridge University Press