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Technical Note

Supplying Hydrogen Water to Ducks Did Not Influence Ammonia Content and Duck Litter Quality

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ABSTRACT

Drinking hydrogen-rich water shows a remarkable antioxidant effect in preventive and therapeutic applications. However, there is no previous report and information on ammonia (NH_3) production and duck litter quality when hydrogen water was supplied to ducks. This study verified the effects of supplying hydrogen water to ducks on NH_3 production and duck litter quality in a duck rearing environment. A total of 1,200 0-d-old Pekin ducks were divided into 2 groups of similar body weight (3 replicates with 200 ducks per pen) and used for 42 days. The two groups consisted of general water and hydrogen water in the water supply system, as the control and treatment groups, respectively. There were no statistical differences between two groups for NH_3 contents for the five weeks ($p>0.05$), except for week 6. For litter quality, no effects ($p>0.05$) between the two water groups were found in the pH, total nitrogen (TN), ammonia-N (VBN), and VFA content of litter. The only significant difference observed in duck litter quality was litter moisture contents ($p<0.05$). Lastly, mineral and heavy metal contents did not significantly differ between the two water groups. As the first pen trials evaluating the effects of hydrogen water on duck litter, these results verify that supplying hydrogen water to ducks did not influence ammonia and duck litter quality.

INTRODUCTION

A major problem being faced by the poultry industry is the accumulation of large amounts of litter generated through the poultry production cycle (Bolan *et al.*, 2010). These materials are applied to land or reused as litter during the production cycle. Consequently, poultry litter produced through these cycles can have a negative impact on broiler production due to ammonia (NH_3) emission and can result on environmental problems such as eutrophication and soil acidification (Bolan *et al.*, 2010). Besides being used as fertilizer for crop production, which is one of its environmental benefits, poultry litter has also recently been considered as an energy source that can be made available in the form of biogas (Dalólio *et al.*, 2017; Pedroza *et al.*, 2021). However, to keep the continued productivity, profitability, and sustainability of duck litter in farms, alternative choices are still needed. An alternative choice could be drinking hydrogen-rich water, as this has been reported to have antioxidant effects on aging tissues (Tomofuji *et al.*, 2014). Zhang *et al.* (2016) reported that pre-treatment with hydrogen-rich water mitigated depressive-like behaviors in mice through the suppression of the inflammasome activation. Based on these results, we hypothesized that supplying hydrogen-rich water to ducks could have an effect on NH_3 production and litter quality. However, there had previously been no studies evaluating the effect of hydrogen-rich water on duck litter.

Thus, the objective of this study was to verify the effects of supplying hydrogen water to ducks on NH_3 production and duck litter quality in a duck rearing environment.

MATERIALS AND METHODS

This experiment was carried out on Gilheung duck farms (Geochang, South Korea), according to the animal care and use committee guidelines. A total of 1,200 0-d-old Pekin ducks were randomly distributed based on similar body weight (50.8 ± 1.22 g) between two groups of three replicates with 200 ducks per pen. The two groups consisted of general water from a water supply system (the control group) and hydrogen water (T1) system, as shown in Figure 1. The hydrogen water generating system was provided by IBIRDIE Co (Seoul, South Korea). Water supply from the control and T1 and the feed were available *ad libitum* during the entire experimental period. Ducks were fed a commercial basal diet in two steps: grower ration (0 to 21 d; 21.5% crude protein [CP], 0.4% Ca, and 1.5% P) and finisher ration (22 to 42 d; 17.0% CP, 0.40% Ca, and 1.0% P). Ducks were kept in six pens in an environmentally controlled, slatted-floor facility. Each pen (10 × 7 m) was equipped with a feeder and shared-through nipple drinkers, with approximately 8 cm of litter (rice hulls and wood shavings). The temperature was maintained at 33°C during the first weeks, and reduced gradually by 2–3 °C every week until a temperature of 22~23°C was reached. The lighting was 14/10-h light/dark cycle, and the relative humidity was 50~65%. Ventilation systems were available and automatically adjusted according to the growth stage of ducks.

A

B

Figure 1 – Photographs showing the water systems used in the study: (A) general water system and (B) hydrogen water system.

At the end of the experiment duration (42 d), litter samples from each pen were collected from 12 places, including either side of the feeder or water supply and the center of the pen. Collected samples were thoroughly mixed by hand, and approximately 100 g were weighed. Samples were kept in a plastic bag and maintained frozen for the determination of pH and moisture, total nitrogen (TN), NH_3-N (VBN), and volatile fatty acid (VFA) contents. Ammonia emissions from duck litter were determined weekly at eight random locations using the multi-gas analyzer (Yes Plus LGA, Critical Environment Technologies Canada Inc., Delta, Canada).

Litter pH was determined using a 1:10 (litter:water) extraction ratio. Samples were extracted for 2 h using a mechanical shaker, and then centrifuged at 3,000 rpm for 10 min. Aliquots of supernatant samples were collected in 1,000-mL screw cap glass bottles for determination of pH and VFA (Muck & Dickerson, 1988). pH was also immediately measured using a pH meter (Metrohm/Brinkmann 691, ALT, Connecticut, USA). Volatile fatty acid content was determined through high performance liquid chromatography (HPLC) using a UV detector (Spectroflow 757, ABI Analytical Kratos Division, Ramsey, USA). Moisture and TN contents of the litter were analyzed using AOAC (1990) methods. VBN was measured by the colorimetric method, as described by Chaney & Marbach (1962). For the determination of Ca and P or heavy metals (Cd, Pb and Hg) at 42 d, the two water samples were examined by inductively coupled plasma atomic emission spectroscopy (ICP-AES) (Perkin Elmer, Norwalk, CT, USA).

Values are presented as mean ± standard error (SE). All data were analyzed using the procedure of the SAS Institute (SAS, 1996). Means were compared through T-test. Statements of significance were based on the 0.05 probability level.

RESULTS AND DISCUSSION

The effect of hydrogen water on duck litter NH_3 contents is shown in Table 1. There were no statistical differences between the two groups in terms of the NH_3 contents through the five weeks ($p>0.05$). On the other hand, the difference found in duck NH_3 contents between groups after six weeks was significant ($p<0.05$) (Table 1). NH_3 contents tended to be slightly increased for the control and T1 group as a function of week. Also, NH_3 production in the T1 group was higher than in the control, which was likely due to higher litter pH after 6 weeks (Table 2). The data obtained from the current study suggests that supplying hydrogen water to ducks did not reduce NH_3 production in the duck litter during the experimental period. Generally, increasing NH_3 volatilization in poultry litter decreases litter N content, which is a significant loss in terms of fertilizer values (Tabler, 2006) and has negative impacts on poultry health and safety in the facilities (Ritz *et al.*, 2004). The recommended range for NH_3 exposure levels in poultry houses is 20–25 ppm (Atapattu *et al.*, 2017); thus, our results were within the recommended range.

Table 1 – Effect of hydrogen water on ammonia contents from duck litter.

Item	Treatment		Significance
	Control	Hydrogen water	
0 week	0.0±0.00	0.0±0.00	NS[1]
1 week	0.0±0.00	0.0±0.00	NS
2 week	2.3±0.20	2.9±0.11	NS
3 week	4.5±0.55	6.2±0.59	NS
4 week	10.0±0.66	11.8±1.61	NS
5 week	16.5±0.87	17.1±1.66	NS
6 week	15.3±0.42	18.0±0.69	*

Means±SE (Standard error).

[1]NS: not significant.

*$p<0.05$.

Table 2 presents the effect of hydrogen water on duck litter quality after 42 d. There were no effects ($p>0.05$) on litter pH, TN, VBN, and VFA contents between the two water system groups, except for litter moisture contents ($p<0.05$). In the current study, one of the most important factors causing an increase in duck litter NH_3 concentrations was the increase in litter pH and moisture (Reddy *et al.*, 1979; Carr *et al.*, 1990); that is, NH_3 concentrations rapidly increased once litter pH increased above 8 at 6 weeks (Table 2). Contrary to our study, Anderson *et al.* (2020) explained that higher litter moisture contents observed at the start after using alum and alum mud litter amendment (AMLA) are due to the acidity from these amendments being neutralized relatively early. The difference in these two studies is not the acidity of the two waters used in our study. In terms of TN and VBN contents, there was no remarkable difference between the two groups. Additionally, it is important to understand that the group with a higher N content had a reduction in NH_3 emissions under duck litter or duck facilities (Choi & Moore, 2008). In other words, the same patterns seen between the two water supply systems in terms of the TN and VBN contents are due to the lack of acidifying agents. Although VFA contents did not differ between the two water groups, VFA contents in duck litter were greater among those supplied with general water than those supplied with hydrogen water. Among the VFAs, acetic acid and propionic acid were commonly observed in these two water groups (not butyric acid, isobutyric acid, valeric acid, or isovaleric acid). Also, Cheah *et al.* (2019) reported that alkaline conditions in using food wastes enhanced VFA production, which was obtained under acidic conditions for acetic acid-dominant VFA production (up to 91 % of the VFA spectrum). Miller & Varel (2001) found that the activity of the VFA-utilizing microorganisms was inhibited by low manure pH. According to other reports, pH is a well-known parameter that can lead to the production of VFA during hydrolysis or under an acidogenic status (Begum *et al.*, 2018). At present, the VFA mechanism behind our results is unclear.

Table 2 – Effect of hydrogen water on duck litter quality after 42 days.

Item	Treatment		Significance
	Control	Hydrogen water	
pH	8.95±0.15	9.10±0.11	NS[1]
Moisture (%)	63.2±0.91	58.1±1.11	*
Total nitrogen (%)	0.90±0.01	0.86±0.55	NS
Ammonia-N (VBN, %)	0.18±0.03	0.12±0.01	NS
VFA (%)			
Acetate	0.92±0.24	0.59±0.25	NS
Propionate	0.29±0.03	0.14±0.07	NS

Means±SE (Standard error).

[1]NS: not significant.

*p<0.05.

The effect of hydrogen water on the mineral and heavy metal contents of the two water systems are summarized in Table 3. Overall, the mineral and heavy metal contents obtained after 42 d did not significantly differ between the two groups (*p*>0.05). The results also show no significant difference between the two water system groups. A difference was observed in terms of the Ca content; however, this was not significant.

Table 3 – Effect of hydrogen water on mineral and heavy metal contents from two water systems.

Item (mg/L)	Treatment		Significance
	Control	Hydrogen water	
Ca	19.18±0.37	18.60±0.16	NS[1]
P	0±0.00	0±0.00	NS
Cd	0±0.00	0±0.00	NS
Pb	0±0.00	0±0.00	NS
Hg	0±0.00	0±0.00	NS

Means±SE (Standard error).

[1]NS: not significant.

In conclusion, supplying hydrogen water to ducks instead of water from a general water supply did not show significant effects, as demonstrated by the NH_3 content, litter quality, and mineral and heavy metal contents observed between the two types of water systems. The reasons for there being no difference between the two water groups is not acidity.

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REFERENCES

Anderson K, Moore PA Jr, Martin J, Ashworth AJ. Effect of a new manure amendment on ammonia emissions from poultry litter. Atmosphere 2020;11:257.

Atapattu NSBM, Lakmal LGE, Perera PWA. Effects of two litter amendments on air NH3 levels in broiler closed-houses. Asian-Australians Journal of Animal Science 2017;30(10):1500-1506.

AOAC - Association of Official Analytical Chemist. Methods of analysis. 15th ed. AOAC, Washington; 1990.

Begum S, Anupoju GR, Sridhar S, Bhargava SK, Jegatheesan V, Eshtiaghi N. Evaluation of single and two stage anaerobic digestion of landfill leachate: effect of pH and initial organic loading rate on volatile fatty acid (VFA) and biogas production. Bioresource Technology 2018;251:364-373.

Bolan NS, Szogi AA, Chuasavathi T, Seshadri B, Rothrock MJ, Panneerselvam P. Uses and management of poultry litter. World's Poultry Science Journal 2010;66:673-698.

Carr LE, Wheaton FW, Douglass LW. Empirical models to determine ammonia concentrations from broiler chicken litter. Transactions of the ASAE 1990;33:1337-1342.

Cheah YK, Vidal-Antich C, Dosta J, Mata-Álvarez J. Volatile fatty acid production from mesophilic acidogenic fermentation of organic fraction of municipal solid waste and food waste under acidic and alkaline pH. Environmental Science and Pollution Research 2019;26:35509-35522.

Chaney AL, Marbach EP. Modified reagents for determination of urea and ammonia. Clinical Chemistry 1962;8:130-132.

Choi IH, Moore PAJr. Effects of liquid aluminum chloride additions to poultry litter on broiler performance, ammonia emissions, soluble phosphorus, total volatile fatty acids, and nitrogen contents of litter. Poultry Science 2008;87:1955-1963.

Dalólio FS, Silva JN da, Oliveira ACC de, Tinôco IDFF, Barbosa RC, Oliveira Resende M de, *et al.* Poultry litter as biomass energy: a review and future perspectives. Renewable & Sustainable Energy Reviews 2017;76:941-949.

Miller DN, Varel VH. Effect of nitrate and oxidized iron on the accumulation and consumption of odor compounds in cattle feedlot soilsin Proceedings of the 2001 International Symposium; 2001; Raleigh: North Carolina State University, Raleigh; 2001. p.84-92

Muck RE, Dickerson JT. Storage temperature effects on proteolysis in alfalfa silage. Transactions of the ASAE 1998;31:1005-1009.

Reddy KR, Khaleel R, Overcash MR, Westerman PW. A nonpoint source model for land areas receiving animal wastes: II. Ammonia volatilization. Transactions of the ASAE 1979;22:1398-1405.

Pedroza MM, Silva WG da, Carvalho LS de, Souza AR de, Maciel G.F. Methane and electricity production from poultry litter digestion in the amazon region of Brazil: a large-scale study. Waste and Biomass Valorization 2021;12:5807-5820.

Ritz CW, Fairchild BD, Lacy MP. Implications of NH3 production and emissions from commercial poultry facilities: a review. Journal of Applied Poultry Research 2004;3:684-92.

SAS. User's guide: statistics. Cary: Institute SAS; 1996.

Tabler GT. Ammonia emissions attracting significant attention. Avian Advice 2006;8(2):9-11.

Tomofuji T, Kawabata Y, Kasuyama K, Endo Y, Yoneda T, Yamane M, *et al.* Effects of hydrogen-rich water on aging periodontal tissues in rats. Scientific Reports 2014;4:5534.

Zhang Y, Su WJ, Chen Y, Wu TY, Gong H, Shen XL, *et al.* Effects of hydrogen-rich water on depressive-like behavior in mice. Scientific Reports 2016;6:23742.