Impact of chlorine dioxide as water acidifying agent on the performance, ileal microflora and intestinal histology in quails

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Summary

The present study was planned to investigate the effect of different levels of chlorine dioxide on the performance, gut microbiota and intestinal histology of quails. For this purpose, 300 dayold healthy quail chicks were randomly placed in 20 specially designed pens (15 birds/pen) with water troughs containing chlorine dioxide at the level of 0.00 (DW-0.00), 0.3 (DW-0.3), 0.4 (DW-0.4) and 0.5ppm (DW-0.5) in replicated fashion (5 replicate/treatment) for 28 days. Weight gain, feed conversion ratio and dressing percentage increased significantly (P<0.05) in DW-0.5 group. Similarly, liver, gizzard and heart weight increased significantly in treated groups linearly with increasing levels of treatment at day 21 and 28. The results showed that population of Salmonella and E. coli decreased linearly at day 21 and 28 of age. Villus height and goblet cells at day 21 and 28 were significantly higher in DW-0.5 group. The results of the present study suggested that the treatment of chlorine dioxide linearly increased the performance and gut morphology and decreased microbial population in quails.

Keywords: quails, chlorine dioxide, performance, Salmonella, E. coli, gut morphology

Introduction

Water is one of the most important and essential nutrients in poultry production. Requirement of water is about two times greater than feed under optimum environmental conditions. Onset of mortality is possible if birds remain deprived of water even for a short period of time compared to feed deprivation (Watkins & Tabler 2009). Water acts as a solvent in various biological processes e.g. assimilation, digestion and absorption and regulation of body temperature. Water also provides the essential medium for almost all necessary chemical reactions required for the formation of useful products like eggs and meat. It also helps in the process of secretion, excretion and lubrication (Koelkebeck et al. 1993). Any deviation of standards in water quality may ultimately affect health status and production of poultry birds (Zimmermann & Douglass 1998). Water is supplied in ample amounts in commercial poultry farms without giving any proper consideration to water quality (Narkis et al. 1995). Many management factors, when disturbed in a poultry production system, can compromise bird performance but this condition could be more devastated with bad water quality (Leung et al. 2007). Physical, chemical and biological properties of water should be considered seriously in any poultry operation. Transmission of viral, protozoal and bacterial diseases increases with contaminated drinking water (Hinton et al. 1990). Poor quality of drinking water provides a favourable environment for the growth of harmful pathogens (Andrews et al. 1995). Vaccines, vitamins and other medicines were effective and readily absorbed by the body with good quality of water (Zimmerman & Hilton 1995). Presence of organic materials in drinking water promotes the growth of bacteria, especially when poultry droppings are accidentally getting access to the drinking water system (Blake & Hess 2001). There were various other factors that can affect the water quality, including water source. The biofilm formed on the surface of water acts as a nest for microbes especially bacteria (Hancock et al. 2007). Water-born diseases in broiler production can be prevented by the protection of supply sources and water disinfection (Belluati et al. 2007). Moreover, factors of quality control like chemical, physical and microbiological characteristics are essential to prevent disease occurrence (Belluati et al. 2007). Water is a fundamental nutrient for avian, therefore its quality preservation is of prime importance to have a good flock performance (Wabeck et al. 1994).

Different methods can be used to eliminate or at least to minimize the impurities in drinking water. Various kinds of antibiotics, organic acids and sanitizers were used in the treatment of bad quality water to avoid its hazardous effects (Belluati et al. 2007). The use of these and other chemicals in huge quantity for water treatment can affect bird's performance negatively and is proven to be expensive (Gagnon et al. 2005). In broiler production, one of the efficient control strategies is the addition of acids or chlorine to drinking water (Tian et al. 2010). Chlorine dioxide (CD) is a yellowish green oxidizing agent, which is one of the potential disinfectants among those unveiled earlier in this century (Clark et al. 2003). The use of CD for the purification and disinfection of drinking water has been approved by the United States Environmental Protection Agency (EPA) along with other application (Ji et al. 2008). Chlorine dioxide is becoming increasingly used for water purification and called the »ideal« biocide because of its unique combination properties (Vicuña-Reyes et al. 2008). At extremely low dosages, it rapidly kills pathogenic microbes, reduces the formation of biofilms with no bad taste, odour and taint problems. Moreover, it is economical and environmentally friendly (Korn et al. 2002). It has the potential to kill different types of spores (Veschetti et al. 2002), yeasts, moulds and viruses (Bichai & Barbeau 2008). To the best of our knowledge, reports dealing with the effect of CD on the production of quails are not available in the literature. Therefore, we planned to investigate the effect of CD on performance traits, Salmonella and E. coli population and gut morphology in Japanese quails.

Material and methods

Prior permission was obtained from the Ethical Committee on care and welfare of animals, Faculty of Animal Husbandry & Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan to conduct this study.

Quail husbandry and experimental design

Two hundred and forty day-old healthy quail chicks were purchased from a commercial supplier of poultry birds at District Peshawar, Pakistan. These birds were randomly placed in 20 specially designed pens and were allotted to four water mixed CD treatments at the rate of 0.00 (DW-0), 0.3 (DW-0.3), 0.4 (DW-0.4) and 0.5ppm (DW-0.5) in replicated fashion (5 replicates/treatment) 15 quail chicks each. Quail birds were given optimal environmental conditions with standard managemental practices (Table 1).

Chlorine dioxide was offered to the birds in three different treatment groups at the dose rate of 0.3ppm, 0.4ppm, and 0.5ppm for 28 days. Chlorine dioxide was obtained from the Duka Production Ltd (Ommen, The Netherlands). Four grams of CD tablet were dissolved in one litre of drinking water to obtain 2 000ppm stock solution. The stock solution was kept in dark to protect from direct sunlight. From the stock solution, 0.14, 0.17 and 0.2ml per litre of drinking water were used to obtain the required concentration of 0.3, 0.4 and 0.5ppm of CD in drinking water respectively.

Performance traits

The birds were offered a weighed amount of feed daily from which refused feed was subtracted to get daily feed intake. Daily feed intake was used to work out the weekly feed intake. Weekly weight gains were calculated by subtracting initial weight from final weight of every week. Weekly feed conversion ratio was calculated by dividing weekly feed consumed by weekly weight gain. Dressed weight of body after slaughtering was determined and expressed in term of percentage of whole body weight. Visceral organs i.e., liver, heart, spleen were weighed separately at the end of experiment.

Lower ileal microflora

At day 21 and 28, four birds were randomly selected from each replicate and were slaughtered to collect the sample from lower part of intestine, aseptically. The samples were transported at 4 °C to the Laboratory of Microbiology, Department of Animal Health, University of Agriculture, Peshawar, Pakistan. A loop full of broth was streaked on plates of Salmonella-Shigella agar (Oxoid, Basingstoke, UK). The plates were incubated at 37 °C for 24h. Suspected colonies of Salmonella and E. coli from each plate were collected for presumptive identification based on their morphological characteristics and various biochemical tests that included catalase, oxidase, indole and methyl red test. The bacteria were counted on bacterial counting machine. The bacterial population was measured as log10 cfu/g.

Gut morphology

Four birds per replicate on day 21 and 28 were randomly selected and intestine was removed. One cm segment of the midpoint of the duodenum, jejunum and ileum were removed, placed in physiological saline solution and fixed in 10% buffered-formalin. Each segment was then embedded in paraffin and a 2 μm section of each sample was placed on a glass slide and stained with haematoxylin and eosin for examination (Sakamoto et al. 2000). Histological sections were examined with a microscope. Villus height was measured from the top of the villus to the top of the lamina propria. Fifteen measurements were taken per bird for this variable for purpose of statistical analysis.

Data analysis

Data generated from field and lab work were statistically analysed using standard procedure of the analysis of variance (ANOVA) in a completely randomized design (CRD) as suggested by Steel & Torrie (1980). P-value less than 0.05 was considered as statistically significant.

Results

Feed intake, weight gain, feed conversion ratio and dressing percentage are given in Table 2. It is obvious that feed intake was not significant, although numerically highest feed intake was recorded in control group. Weight gain, feed conversion ratio and dressing percentage increased significantly ($P<0.05$) in DW-0.5 group. The results also indicated that these parameters increased linearly with increasing the level of CD level. Weight of liver, gizzard and heart are given in Table 3. Similarly, liver, gizzard and heart weight increased significantly ($P<0.05$) in treated groups linearly with increasing levels of treatment at day 28. The highest weight gain in liver, gizzard and heart were observed in DW-0.5 group.

Salmonella and E. coli population are given in Table 4 and 5 respectively. The results showed that that the population of Salmonella and E. coli decreased linearly (P<0.05) at day 21 and 28 of age. The least populations of both bacteria were recorded in the group having a CD level of 0.5ppm. The Villus height of control and treated groups are given in Table 6. The results showed that villus height increased significantly (P<0.05) in DW-0.5 on day 21 and 28. The number of goblet cells at day 21 and 28 were significantly higher (P<0.05) in DW-0.5 group (Table 7).

Discussion

In the present study different levels of CD improved weight gain, feed conversion ratio and dressing percentage linearly with increasing level of the treatments. We also found out that by increasing the dose of CD, the pH decreased. Thus it is an alternative to any acidic agent. Studies regarding the use of CD are scarce to compare our results. Desai et al. (2007) reported that combination of formic and propionic acids in the drinking water increased weight gain and improved feed conversion ratio in broilers. The positive effect of treating water with some organic acids on digestion may be due to better absorption of nutrients (van der Sluis 2002). Our result can be correlated to the work of Pesti et al. (2004) who observed that acidified drinking water increased body weight in comparison to normal drinking water given to broilers. The positive effects of CD on birds' performance could be related to its potency to combat harmful microbes and to maintain the gut pH in acid range for activation of digestive enzymes. As a result, the intestinal tract remains healthy and expresses its function fully in terms of more nutrients absorption and assimilation. These findings can be justified by the findings of Chaveerach et al. (2004) who reported that birds offered chemically treated water with organic acids responded better in term of body weight gain. Similarly, Bahnas (2009) also reported on significant increase in body weight gain of Japanese quails by malic acid supplementation.

We found a significant increase in the weight of liver, gizzard and heart in the DW-0.05 group. Results of the present study could be justified by the findings of Islam et al. (2008) who reported on a positive effect on liver weight by supplementing various acidifiers in the diet of boilers. Similarly, in line with present outcomes, Islam et al. (2008) observed that quail birds, given acid treated water, showed a significant effect on the weight of the visceral organs. In the present study, the population of Salmonella and E. coli decreased linearly with the increasing level of CD. Chlorine dioxide is considered as more efficient disinfectant globally over a wide range of pH than other disinfectants and is more potent to inactivate resistant pathogens due to high penetration and absorption of the CD into the bacterial plasma membrane. The mechanism of action of CD is its capability to destroy microbes by increasing bacterial cell membrane permeability where it dissociates into anions and cations upsetting the electron balance inside the bacterial cell and kill it (Huang et al. 1997). It may produce acidic conditions that eradicate the coliform of the gastrointestinal tract by lowering the pH, which is unfavourable for the growth of the acid-intolerant species such as E. coli and Salmonella. In the present study, villus height and goblet cells increased linearly in a significant fashion in the treated groups compared to control. It was assumed that CD has similar mechanism of action to organic acid reducing bacterial and fungal quantity in gut which improves villus height and helps in better nutrient utilization (Paul et al. 2007). The increase in the goblet cell count indicates that gut efficiency to protect itself and to utilize nutrients efficiently was maximized. Goblet cells produce mucus that forms a protective cover on the outer lining of gut (Paul et al. 2007). As discussed earlier there was an increase in the villus height with supplementation of CD that reflects increase in the number of goblet cells. Ferket et al. (2002) reported that turkeys, when fed substances that enhance and improve gut microbial profile, improved goblet cell number in the gut lumen. Similar findings were reported by Smirnov et al. (2005) that coincide with current outcomes.

From the present results, we concluded that treating water with chlorine dioxide increased the production performance, improved gut morphology and decreased the intestinal microflora.

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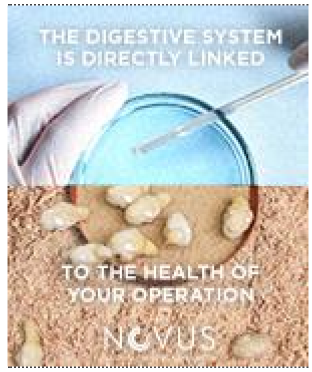
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