INTRODUCTION

The use of drinking water in sufficient amounts and in adequate quality plays an important role in maintaining health and performance for food-producing animals (Kamphues and Schulz, 2002). In broiler chicken production, many chicken houses are equipped with closed drinking systems, which in comparison with open systems, provide a better water quality (Quichimbo et al., 2013). Nonetheless, even in this kind of drinking system, water is often contaminated with pathogens introduced between the water source and the drinkers (Amaral, 2004). However, water quality should be guaranteed not only before entering the chicken house but also in the whole drinking line system until the last day of grow-out (Kamphues et al., 2007). Therefore, water disinfection with different chemical solutions is a usual method to eliminate water as a transmission route for pathogens during the rearing period.

Furthermore, disinfection plays an important role in maintaining the drinking line system. In modern chicken houses, vaccination, medical treatment, and most special treatments (for example, probiotics or organic acids) are administered as water additives. Safety and efficiency of these applications depend on clean drinking lines that are free from nonpathogen contaminants (dust, feeding residues, and so on) and biofilms.

In recent years, increasing attention has been dedicated to electrolyzed oxidizing (EO) water and its antimicrobial effects (Fenner et al., 2006). In poultry production, studies have been carried out in different parts of the production system. Bialka et al. (2004) showed the sanitizing effect of EO water when sprayed on eggshells. Furthermore, EO water could be used for sensitive disinfecting measurement of air and surfaces in layer breeding houses (Hao et al., 2013). By using EO water while rearing broiler chicken, drinking lines could be excluded as a vector for Campylobacter colonization (Bügener et al., 2014). Even at the end of the production chain, EO water showed its effect on disinfecting carcasses after spraying at the slaughterhouse (Northcutt et al., 2007; Rasschaert et al., 2013).

Benefits of neutral electrolyzed oxidizing water as a drinking water additive for broiler chickens

E. Bügener,*† A. Wilms-Schulze Kump,† M. Casteel,‡ and G. Klein*1

*Institute of Food Quality and Food Safety, University of Veterinary Medicine Hannover, Foundation, Bischofsholer Damm 15, D-30173 Hannover, Germany; †WEK Veterinary Practice, Lohe 13, 49429 Visbek, Germany; and ‡WEK Laboratory, Lohe 13, D-49429 Visbek, Germany

ABSTRACT In the wake of discussion about the use of drugs in food-producing farms, it seems to be more and more important to search for alternatives and supportive measures to improve health. In this field trial, the influence of electrolyzed oxidizing (EO) water on water quality, drug consumption, mortality, and performance parameters such as BW and feed conversion rate was investigated on 2 broiler farms. At each farm, 3 rearing periods were included in the study. With EO water as the water additive, the total viable cell count and the number of Escherichia coli in drinking water samples were reduced compared with the respective control group. The frequency of treatment days was represented by the number of used daily doses per population and showed lower values in EO-water-treated groups at both farms. Furthermore, the addition of EO water resulted in a lower mortality rate. In terms of analyzed performance parameters, no significant differences were determined. In this study, the use of EO water improved drinking water quality and seemed to reduce the drug use without showing negative effects on performance parameters and mortality rates.

Key words: electrolyzed oxidizing water, broiler chicken, water additive

2014 Poultry Science 93:2320–2326
http://dx.doi.org/10.3382/ps.2014-03909

© 2014 Poultry Science Association Inc.
Received January 15, 2014.
Accepted June 4, 2014.
1Corresponding author: guenter.klein@tiho-hannover.de

2320
and oxidation-reduction potential (ORP) < -800 mV is produced. On the other side, acidic water with pH < 2.7 and ORP > 1,100 mV is generated (Hsu, 2005). The disinfection mechanism is based on a high ORP, hypochlorous acid, and available chlorine concentration (Len et al., 2000; Park et al., 2004; Liao et al., 2007). Due to its better stability, lower loss of free chlorine, and less corrosion effects, neutral EO water appears to be the most appropriate variant for the use of an EO water generator (Len et al., 2002; Ezeike and Hung, 2004; Ayebah and Hung, 2005). To produce neutral EO water, 5 to 10% of the alkaline EO water has to be mixed with the acidic EO water by a computer-controlled generator. In this way, the neutral EO water solution had a pH of 6.2 to 7.5 and an ORP of 800 to 1,100 mV (Schulz Systemtechnik, 2010). In light of this background, the primary objective of this study was to evaluate the effect of neutral EO water as a permanently administered water additive on water quality and performance of broiler chickens. Furthermore, the aim of this study was to investigate its benefit for the production of a poultry meat product obtained with minimal use of medical treatment.

MATERIALS AND METHODS

Rearing Farms

As part of a field trial, 2 broiler farms were examined for 3 rearing periods under conventional production conditions. The selection of farms was carried out according to criteria regarding type of chicken house, birds, and biosecurity. Chicken houses on each farm were built in the same year and were identical in size. Equipment for water and feed was the same and could be individually operated. On each farm, 2 chicken houses were included in the study. One of these houses served as a control group, whereas the other one was the test group. Two chicken flocks were examined from the same breeder flock. In both houses, chicken consistently received the same feed. Farm A was rearing for integration A. Chickens were slaughtered at slaughterhouses A and B after batch depletion and at slaughterhouse C after main catching. The farm had 2 identical chicken houses, which were connected via a shared anteroom. In every chicken house 35,000 chickens were kept. There was no other broiler farm within a radius of 3 km. The access road was not paved. The area in front of the barn (20 m × 80 m) was concreted. The supply of drinking water in flock 1 occurred with water from an own water-supply well, which was made free from iron by a deferrization unit (Remotecor 2000; Remon water treatment). Flock 1 served as a control group, and flock 2 received the same iron-free drinking water supplemented with 3% neutral electrochemically activated water as a water additive.

Production of EO Water

Neutral EO water was generated using an Agrilyt-Generator (Schulz Systemtechnik GmbH, Visbek, Germany) equipped with a DEA-30 electrolytic cell operating at 24 V DC, 10 A, and 30 L/h (Elliod GmbH, Berlin, Germany). The cell was divided into 2 chambers by a ceramic diaphragm for producing an acidic and a basic solution. To produce a salt solution, NaCl was used (8 kg/m3 of Agrilyt). To produce neutral Agrilyt, 5 to 10% of the full amount of catholyte was mixed with anolyte. The generator consisted of a control cabinet for the electrical component, a control cabinet for the hydraulic components, and a reverse osmosis system. It was installed by the manufacturer and remained in the anteroom throughout the entire duration of the experiment. The device was directly connected to the dispenser at the water supply line, which was normally used for drug administration. The solution was thus produced on site and was added at a concentration of 3% directly into the drinking water. The neutral EO water solution had a pH of 6.2 to 7.5 and an ORP of 800 to 1,100 mV. The amount of residual chlorine was measured using an ExStik CL200 chlorine tester (Extech Instruments Corporation, Nashua, NH); pH and ORP were measured using an Exstik PH100 pH meter and ExStik RE300 ORP tester (Extech Instruments Corporation).

Drinking Water Samples

Before the start of each rearing period at the anteroom, water samples (1 L) were taken before inflow to the drinking line (n = 3).

For 3 rearing periods on d 0, 7, 14, 21, 28, and 35, samples (each 1 L) were taken from the drinking lines in both chicken houses (n = 36). The 1-L sample was a pooled sample of each 250 mL that was taken on the same day from 4 different drinking lines. The pH and ORP levels were measured. Furthermore, the total
viable cell (TVC) count and *Escherichia coli* counts were determined by transferring the water sample into a sterile 100-mL MicroFunnel (Pall Life Sciences, Dreieich, Germany) using membrane filters made of mixed cellulose esters with a pore size of 0.45 μm (GN-6 Metricel, Pall Life Sciences). The MicroFunnel was placed on the aluminum manifold (Pall Life Sciences), and a peristaltic pump drew the whole water sample (1 L) through an integrated system. Subsequently, water samples were analyzed according to ISO 6222 and ISO 9308–1. After performing a serial dilution, all detected coliform bacteria were tested for their tryptophanase activity. Tryptophanase-positive coliforms were recognized as *E. coli*.

The assessment of microbiological drinking water quality was based on the German orientation guidelines for assessing hygienic quality of drinking water given to food-producing animals (German Ministry of Food Agriculture and Consumers’ Protection/BMELV, 2007; Kamphues et al., 2007). In these guidelines the quality of drinking water is specified by the absence of microbiological contaminants. To comply with these requirements drinking water should be free of *Salmonella* spp., *Campylobacter* spp. and *E. coli* (in 100 mL). The total viable cell counts should not exceed 1,000 cfu/mL at 37°C and 10,000 cfu/mL at 20°C. The determination of cfu at 22°C is used to detect autochthonous water organisms. At 37°C, organisms that could be facultative pathogens for birds are aimed to be isolated.

### Zootechnical Parameters

The measurement of feed consumption was made by a feed weigher installed in the chicken house. The feed consumption for every single compartment was determined. During the whole rearing period, mortality rate and BW were documented daily. The BW was daily evaluated by a computer-controlled weigher in each chicken house, which was able to calculate the average BW of the whole flock by the number of weighing per day. The feed conversion rate (FCR) was calculated for the whole duration of every rearing period.

### Medical Treatment

The evaluation of drug use was based on the evaluation method of the German antibiotic monitoring system, which is in force from April 2014. For every group on both farms, the number of used daily doses per population (nUDD<sub>Population</sub>), which represents the frequency of treatment days with the average number of active agents, was calculated. It is based on the number of used daily doses (nUDD).

### Statistical Analyses

Analyses were carried out with SAS 9.3 (Statistical Analysis System, Cary, NC). The significance level was set at $P = 0.05$. Drinking water samples from the control and test group were analyzed using a 2-factorial ANOVA for showing differences of TVC and *E. coli* counts. One-half of the detection limit was used for statistical analyses in water samples in which *E. coli* could not be detected. In this way, the biological variability could be considered. A 2-factorial ANOVA was used to compare the means of BW, FCR, and mortality rate of control and treated groups.

### RESULTS

On farm A in the control groups, the mean water pH was 6.92 and the mean ORP level was 489 mV for 18 water samples from the drinking lines within 3 rearing periods. In treated groups on farm A, a mean pH of 6.73 and a mean ORP level of 803 mV were detected for 18 water samples. On farm B, a mean pH of 7.9 and a mean ORP of 631 mV for 18 water samples were measured from drinking lines within 3 rearing periods. In treated groups on this farm, the mean pH was 7.5 and the ORP value increased by 814 mV on average for 18 water samples. Values of ORP were considerably higher in EO-water-treated groups on both farms. In comparison with the control group, Table 1 shows a reduction of TVC in drinking water of the treated groups on both farms. From d 21 on both farms, the EO water treatment led to reduced TVC counts ($P < 0.05$). Furthermore, the counts of *E. coli* in drinking water samples were reduced ($P < 0.05$; Table 1).

Body weight and FCR are shown in Table 2. Due to variable slaughter dates on both farms (36 to 40 d), the longest common grow-out period (36 d) was chosen as the final weight to obtain reasonably comparable values. Feed conversion was adjusted accordingly. Concerning BW, a trend toward a positive influence of EO water on the treated group was observed at d 30. At d 36, a lower BW in the treated group was observed in 3 rearing cycles of the whole experiment.

Figure 1 shows the mortality rate of birds on both farms. There were just 2 periods that showed higher mortality rates on farm B. In these cases the reason was due to the insufficient quality of the chicks on arrival or the 1-d-old chicks were exposed to intensive stress in transit because of failure in the ventilation system.

The calculated therapy frequency is shown in Table 3. Within 3 rearing periods on farm A, the control group had to be treated 3 times. In the first rearing period at d 24, a lot of chickens showed lameness, joint inflammation, and femoral head necrosis in the control stable. In the following rearing period at d 32, lameness and many cases of femoral head necrosis had to be treated in both the control and treated group. In the last rearing period at d 25, similar problems occurred again in the control group. Thus, the EO water-treated group required 2 treatments less than the control group. The mean calculated therapy index showed a reduction of 1.99 points on farm A.
In the first rearing period on farm B, the control group had to be treated because of lameness, joint inflammation, and femoral head necrosis at d 19. After batch depopulation, watery, frothy diarrhea and wet litter developed a high degree of dysbacteriosis. In this case, both groups had to be treated. The following rearing period started with transport-stressed 1-d-old chicks that had great difficulties in achieving sufficient mobility for starting food and water intake after reaching the chicken house.

Therefore, from d 2 onward, higher mortality and infection of the yolk sacs caused by \textit{E. coli} followed. To prevent excessive mortality, chicks in the control and treated group received antibiotic treatment. After batch depopulation (at d 30), an infection with \textit{Orihithobacterium rhinotracheale} was detected by PCR after significant clinical respiratory symptoms. Both groups had to be treated. The final rearing period on this farm again started with an \textit{E. coli} yolk sac infection that became evident at d 2. The control group received antibiotic treatment. In 3 rearing periods on farm B, 5 antibiotic treatments were used in the control group. The test group with EO water was treated 3 times. Subsequently, the therapeutic index in the test group was 3.4 points lower.

**DISCUSSION**

Analyses of the effects of EO water have been carried out mainly with regard to the disinfecting effect. Thus, Park et al. (2008) showed the improvement of a higher quality of vegetables by reducing surface bacterial loads. Furthermore, EO water was used to disinfect a variety of other products and surfaces in the food industry (Ayebah and Hung, 2005; Huang et al., 2008) as well as in animal production (Jirhotková et al., 2012; Bodas et al., 2013). A particular advantage is its biodegradation and harmlessness to health (Morita et al., 2011). The disinfecting effect of EO water and its resulting improvement of water quality were confirmed in this study. A good water quality and adequate amounts of water were considered prerequisites for the health and performance of food-producing animals (Kamphues and Schulz, 2002). Drinking water of food-producing animals should be free from \textit{E. coli} (in 100 mL) and TVC counts should be <1,000 cfu/mL at 37°C and not more than 10,000 cfu/mL at 20°C (German Ministry of Food Agriculture and Consumers’ Protection/BMELV, 2007).

However, in this field experiment no continuous reduction of TVC counts could be shown during the rearing period. Hence, the results do not support the hypothesis that a decrease in TVC counts in drinking water samples results in a reduced incidence of 

**Table 1.** Total viable cells (TVC; log_{10} cfu/mL) detected at an incubation temperature of 37°C for detecting facultative pathogens and \textit{Escherichia coli} counts in drinking water samples\(^1\).\(^2\)

<table>
<thead>
<tr>
<th></th>
<th>TVC count (37°C)</th>
<th></th>
<th></th>
<th></th>
<th>E. coli count</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Control</td>
<td>EO water</td>
<td>SD</td>
<td>(P)-value</td>
<td>Control</td>
<td>EO water</td>
<td>SD</td>
</tr>
<tr>
<td>Farm A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1.37</td>
<td>0.32</td>
<td>0.65</td>
<td>0.184</td>
<td></td>
<td>n.d.</td>
<td>n.d.</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>4.43</td>
<td>2.48</td>
<td>1.11</td>
<td>0.163</td>
<td></td>
<td>1.32</td>
<td>n.d.</td>
<td>0.28</td>
</tr>
<tr>
<td>14</td>
<td>4.25</td>
<td>2.17</td>
<td>0.70</td>
<td>0.068</td>
<td></td>
<td>1.35</td>
<td>n.d.</td>
<td>0.33</td>
</tr>
<tr>
<td>21</td>
<td>4.73</td>
<td>1.21</td>
<td>0.21</td>
<td>0.002</td>
<td></td>
<td>2.05</td>
<td>n.d.</td>
<td>0.05</td>
</tr>
<tr>
<td>28</td>
<td>4.60</td>
<td>1.75</td>
<td>0.53</td>
<td>0.023</td>
<td></td>
<td>1.75</td>
<td>n.d.</td>
<td>0.16</td>
</tr>
<tr>
<td>35</td>
<td>5.13</td>
<td>2.14</td>
<td>0.41</td>
<td>0.012</td>
<td></td>
<td>1.73</td>
<td>n.d.</td>
<td>0.37</td>
</tr>
<tr>
<td>Farm B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.23</td>
<td>1.55</td>
<td>1.20</td>
<td>0.229</td>
<td></td>
<td>1.65</td>
<td>n.d.</td>
<td>0.44</td>
</tr>
<tr>
<td>7</td>
<td>3.48</td>
<td>1.75</td>
<td>0.90</td>
<td>0.143</td>
<td></td>
<td>1.93</td>
<td>n.d.</td>
<td>0.13</td>
</tr>
<tr>
<td>14</td>
<td>4.96</td>
<td>1.10</td>
<td>1.40</td>
<td>0.078</td>
<td></td>
<td>2.34</td>
<td>0.54</td>
<td>0.39</td>
</tr>
<tr>
<td>21</td>
<td>4.60</td>
<td>2.29</td>
<td>0.19</td>
<td>0.004</td>
<td></td>
<td>2.13</td>
<td>0.59</td>
<td>0.45</td>
</tr>
<tr>
<td>28</td>
<td>4.56</td>
<td>1.98</td>
<td>1.26</td>
<td>0.129</td>
<td></td>
<td>0.91</td>
<td>n.d.</td>
<td>0.75</td>
</tr>
<tr>
<td>35</td>
<td>4.33</td>
<td>2.45</td>
<td>0.16</td>
<td>0.005</td>
<td></td>
<td>2.48</td>
<td>n.d.</td>
<td>0.72</td>
</tr>
</tbody>
</table>

\(^1\)Detection limit: 1 organism per 100 mL.  
\(^2\)According to each day of sampling, water samples of 3 rearing periods (\(n = 3\)) were log-transformed and represented as means with SD.  
\(^3\)n.d.: not detected.

**Table 2.** Means of BW and feed conversion ratio (FCR) after batch depopulation (d 30) and after main catching (d 36) of 2 farms with 3 rearing periods each

<table>
<thead>
<tr>
<th>Rearing period</th>
<th>Farm A</th>
<th></th>
<th></th>
<th></th>
<th>Farm B</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period I</td>
<td>Period II</td>
<td>Period III</td>
<td>SD</td>
<td>(P)-value</td>
<td>Period I</td>
<td>Period II</td>
<td>Period III</td>
</tr>
<tr>
<td>BW, 30 d,(^1) g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1,573</td>
<td>1,531</td>
<td>1,623</td>
<td>10.80</td>
<td>0.607</td>
<td>1,539</td>
<td>1,451</td>
<td>1,491</td>
</tr>
<tr>
<td>EO water</td>
<td>1,581</td>
<td>1,509</td>
<td>1,649</td>
<td>18.90</td>
<td>0.393</td>
<td>1,475</td>
<td>1,486</td>
<td>1,500</td>
</tr>
<tr>
<td>BW, 36 d,(^1) g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2,082</td>
<td>2,049</td>
<td>2,077</td>
<td></td>
<td></td>
<td>1,972</td>
<td>1,942</td>
<td>1,994</td>
</tr>
<tr>
<td>EO water</td>
<td>2,040</td>
<td>2,041</td>
<td>2,097</td>
<td></td>
<td></td>
<td>1,982</td>
<td>1,977</td>
<td>1,976</td>
</tr>
<tr>
<td>FCR, kg of feed/kg of gain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.64</td>
<td>1.62</td>
<td>1.64</td>
<td>0.01</td>
<td>0.270</td>
<td>1.60</td>
<td>1.61</td>
<td>1.61</td>
</tr>
<tr>
<td>EO water</td>
<td>1.61</td>
<td>1.62</td>
<td>1.64</td>
<td></td>
<td></td>
<td>1.61</td>
<td>1.62</td>
<td>1.59</td>
</tr>
</tbody>
</table>

\(^1\)BW on average of 40,000 broiler chicken at farm A and 35,000 broiler chicken at farm B. EO = electrolyzed oxidizing.
spective rearing period (Table 1). This is related to the reentry of microorganisms from the environment of the birds. Furthermore, because of a low flow rate in water pipes and high temperatures at the beginning of the rearing period, in many cases the formation of a biofilm occurred during rearing. The organisms in biofilms form matrices that are irreversibly associated with a surface and enclosed in extracellular polymeric substances (Donlan, 2002; Hall-Stoodley et al., 2004). Protection by the matrix and a slow uptake of antimicrobial agents are the supposed reasons for a higher resistance of bacteria in biofilms (Anwar et al., 1992; Brown and Gilbert, 1993; Donlan and Costerton, 2002). Most of the bacteria in a drinking water system is located at the surface of biofilms, whereas a small fraction is found in the water phase. Only this part is considered when sampling as commonly performed for routine quality control (Flemming et al., 2002).

The TVC counts and the counts of *E. coli* showed a decrease compared with the respective control group (Table 1). These results were consistent with studies of Bodas et al. (2013) that showed lower counts of TVC in drinking water of dairy ewes in a test period of 25 d. Studies of Zeng et al. (2010) on the disinfection mechanism of EO water revealed leakages of DNA and damage to membrane and nucleus as well as a decrease of dehydrogenase activities of *E. coli* and *Staphylococcus aureus*, which resulted in inhibition of respiration and anabolism.

However, not only the benefits of EO water on drinking water quality but also the health status of broiler chickens were investigated in this field experiment. Nevertheless, to make statements about the effects of EO water on the health status of chicken, it is necessary to consider the entire herd. To evaluate the herd health status, different parameters such as BW, FCR, and mortality could be used. Alongside mortality, Dickhaus (2010) mentioned the use of drugs as a direct health indicator. The reduced use of antimicrobial substances contributes to better animal health (Meemken et al., 2014).

In the present study, performance-oriented data (BW, FCR, mortality) as well as drug use were examined. Even after 6 rearing periods, no significant differences in the average BW and the FCR could be determined. Similar observations in poultry were made in the study of Berk et al. (2005), which was not a field trial. Therefore, it should be noted that the comparability is limited due to the housing conditions in experimental cages.

The mortality rate was investigated after the first week and after main catching. Thus, lack of chick quality and frequently occurring young chick diseases could be considered separately from the rest of the rearing period. It might be assumed that EO water-treated chicks may have a lower load of *E. coli* that resulted in a lower mortality rate. Nonetheless, this had to be a hypothesis because the load of *E. coli* in chicks after leaving the hatchery was not measured and the results were not significant (*P* > 0.05). In contrast to results of this study, Fasenko et al. (2009) showed a significantly lower cumulative mortality for the first 14 d of rearing. However, it should be pointed out that Fasenko et al. (2009) sprayed EO water on eggs in the hatchery. Therefore, the bacterial load of eggs was already decreased before hatching. Perhaps young chick diseases such as yolk sac inflammations caused by *E. coli* are not clinically

---

**Table 3.** Average frequency (d) of antibiotic therapy number of used daily doses per population

<table>
<thead>
<tr>
<th>Item</th>
<th>Farm A</th>
<th>Farm B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.66</td>
<td>8</td>
</tr>
<tr>
<td>EO water</td>
<td>1.67</td>
<td>4.6</td>
</tr>
</tbody>
</table>

1Values are the means of 3 rearing periods.

---

**Figure 1.** Cumulative mortality rate of a control group and an electrolyzed oxidizing (EO)-water-treated group in 2 chicken rearing farms. Values of each day of rearing shown at this figure are the mean of 3 rearing periods.
apparent. Adding EO water to the drinking water does not seem to affect existing infections but is obviously able to prevent new infections.

This prevention effect is also reflected by the drug use in this study. During the rearing periods, the influence of EO water on bird health was revealed through the reduced nUDD_Population in comparison with the control group. The nUDD_Population specifies the number of days that an animal of a population was treated with a single active agent on average during the rearing period (Merle et al., 2012). The number of treatments with active agents in a rearing period represents in some way the number of diseases in the population and is therefore suitable for describing the animal health of a population (van Rennings et al., 2013). Against the backdrop of increasing evidence of resistance to antibiotics even in commensals (Leuschner et al., 2010), the number of antibiotic treatments is a critical factor. It is the policy of the European Commission to prevent antibiotic resistances, which are considered to be one of the major emerging threats to human health (European Commission, 2011).

Each treatment of a specific disease also leads to the selection of the normal accompanying bacterial flora and promotes resistant organisms. The nUDD_Population was used for quantification of antibiotic treatments in the 16th revision of the medicinal law in Germany, which comes into force in 2014. Such a collection of data on used antimicrobial agents is demanded by the European Union, which seeks a standardized solution of documentation on antibiotic agents (European Medicines Agency, 2012).

Thus, many environmental influences in the husbandry of broiler chickens can have a large effect on health and welfare (Estevéz, 2007). Nevertheless, the use of EO water as a supplementary measure can be considered to permanently achieve a better drinking water quality and had no negative effects on bird health and performance. Furthermore, the use of EO water contributes to current European Union requirements regarding the reduction of using antibiotic substances.

REFERENCES


