

THE IMPACT OF A BIOFILM REMOVAL FROM WATER SUPPLY SYSTEMS ON THE PRODUCTIVITY OF CHICKENS AND THE BALANCE OF MINERAL SUBSTANCES

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Abstract. Most of the branches of agricultural industry are aimed at the production of qualitative, safe and a wide range of products, and this is particularly relevant in poultry farming. One of the potential sources of poultry infection is water because through it pathogens of salmonellosis and campylobacteriosis infections are transferred to the entire flock on the farm. The trial included two groups (trial and control) with 27 600 one-day-old chickens in each. The drinking water of the chickens of the trial group was treated with the device AQUA 4DPRO60 which treats water with electromagnetic vibrations and destroys the biofilm. Moreover, this device also influences different processes taking place in the water. The following results were obtained: better growth of the birds ($p < 0.05$), the improved liveability and significantly decreased litter moisture ($p < 0.05$). The amounts of major minerals in the blood serum of birds were within the physiological limits. The amount of phosphorus and calcium in tibia of the birds in the trial group was higher in comparison with the control group ($p < 0.05$).

Keywords: chickens, drinking water, biofilm, productivity, mineral substances.

BIOPĖVELĖS PAŠALINIMO IŠ VANDENS TIEKIMO SISTEMŲ NAUDA VIŠČIUKŲ PRODUKTYVUMUI, KRAUJO MAKROELEMENTŲ IR ELEKTROLITŲ PUSIAUSVYRAI

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Santrauka. Dauguma žemės ūkio produktų gamybos šakų orientuotos į kokybiškų, saugių produktų gamybą, ypač – paukštinkystė. Paukštiena pripažinta ir vienu pagrindinių kelių, kuriuo zoonozinių ligų sukėlėjai patenka į žmonių maisto grandinę, todėl daug dėmesio skiriama jiems nustatyti ir pašalinti. Vienas iš galimų paukščių infekcijos šaltinių yra vanduo, su kuriuo prasidėjusios infekcijos, tokios kaip salmoneliozė, kampilobakteriozė, sukėlėjai pernešami visam auginamam pulkui. Bandymui buvo sudarytos dvi grupės (kontrolinė ir bandomoji), po 27 600 vienadienių viščiukų. Bandomosios grupės viščiukų geriamajam vandeniui apdoroti panaudotas prietaisas AQUA 4DPRO60, kuris elektromagnetiniais virpesiais apdoroja vandenį ir sunaikina bioplėvelę, taip pat veikia kitus vandenyje vykstančius procesus. Gauti tokie rezultatai – paukščiai augo geriau ($p < 0,05$), daugiau jų buvo išsaugota, ženkliai sumažėjo kraiko drėgnumas ($p < 0,05$). Paukščių kraujo serumo makroelementų ir elektrolitų kiekis atitiko fiziologinę normą. Fosforo ir kalcio bandomosios grupės paukščių *tibia* organizme buvo daugiau nei kontrolinių ($p > 0,05$).

Raktažodžiai: viščiukai broileriai, geriamasis vanduo, bioplėvelė, produktyvumas, mineralinės medžiagos.

Introduction. The European Union has been improving laws and aid programs in order to guarantee food safety and quality. It might be surprising for majority of people living in the society of modern technologies that food may become a problem. Most of the branches of agricultural industry are aimed at the production of qualitative, safe and a wide range of products, and this is particularly relevant in poultry farming (FSA, 2003). However, poultry is recognized as one of the main roads by which zoonotic pathogens enter the chain of human food; therefore, much attention is given to their identification and elimination on the farm (ACMF, 2005). One of the potential sources of poultry infection is water because with its help pathogens of salmonellosis and campylobacteriosis are transferred to the entire flock on the farm (Byrd *et al.*, 2001; Chaveerach *et al.*, 2004; Winchell, 2001; Zimmer *et al.*, 2003). It is therefore very important that chickens receive water of good quality (Manning *et*

al., 2007).

Water is a vitally important substance which is not only a neutral solvent of various substances but is also related to the processes of digestion, nutrient absorption as well as excretion of metabolism products (Feddes *et al.*, 2002; Jafari *et al.*, 2006). Moreover, water metabolism in the body is closely related to the metabolism of mineral substances (Smith *et al.*, 2000); therefore, water treatment on poultry farms has been gaining more and more popularity in Europe (Pattison, 2001). Seeking to reduce microbial contamination of water, poultry producers treat drinking water of birds with various chemical substances. These substances i. e. chlorine, chlorine dioxide, organic acids, peracetic acid, hydrogen peroxide, etc. affect water only at a certain temperature and at a certain pH of water (Chlorine Dioxide, 2008; Sparks, 2009). They are efficient only for a certain period of time. Afterwards the procedures have to be repeated, and they

require additional costs and are time-consuming. A number of poultry producers, applying chemical methods while raising birds, treat water only one or two days a week, and some of them limit themselves to treating water only at the end of the production cycle. However, it appears that there is a lack of optimal methods for the use of these measures to reduce pathogenic microflora in the water, and thus reducing potential waterborne infections (Sparks, 2009).

It has been determined by researchers that one of the causes of these most common infectious diseases is a biofilm developed inside water supply pipes and a collection of the propagating microorganisms on it, which is surrounded by the slime they secrete and attached to the inert surface or floating in water (Ogden *et al.*, 2007). A biofilm consists of water, bacteria, suspended solids, corrosion products, algae, yeasts/molds, protozoa and molluscs (Coetser and Cloete, 2005). More than 99 per cent of all bacteria live in a biofilm community. A biofilm is like a living tissue on the pipe surface. The development of a mature biofilm may take from several hours to several weeks (Costerton *et al.*, 1987; Mittelman, 1985).

Biofilm bacteria excrete extracellular polymeric substances (glycocalyx), or sticky polymers, which hold the biofilm together and attach it to the pipe wall. In addition, these polymer strands trap scarce nutrients and protect bacteria from biocides. Attachment is mediated by extracellular polymers that extend outward from the bacterial cell wall. This polymeric material consists of charged and neutral polysaccharide groups that not only facilitate attachment but also act as an ion-exchange system for trapping and concentrating trace nutrients from the overlying water. The glycocalyx also acts as a protective coating of the attached cells which mitigates the effects of biocides and other toxic substances (Costerton *et al.*, 1981; Mittelman, 1985).

In order to kill the bacteria responsible for forming a biofilm, a disinfectant must first affect the surrounding protective glycocalyx. It requires a higher concentration and a longer contact time for the disinfectant to reach the bacterial cells in a biofilm compared to free-floating microorganisms. The following factors have an impact on the development of biofilms in water systems: temperature of the environment and the system; water flow rate; nutrient availability; roughness inside the pipes; pH of the water (an approximately neutral pH of the water is optimal for the growth of biofilm-forming bacteria); particulate matters which can become entrapped in the developing biofilm and provide additional attachment sites; efficiency of biofouling control measures (Mittelman, 1986). The developed biofilm causes the deterioration in the microbiological quality of water, induces biocorrosion and biofouling (Coetser and Cloete, 2005).

Swiss scientists have developed a device AQUA 4DPRO60 whose operation is based on physical rather than chemical water treatment. This device treats water with electromagnetic vibrations, and thus influences different processes taking place in the water, and first of all, it destroys the biofilm. In addition, due to electromagnetic vibrations produced by this device, the insoluble calcite in

the water transforms into amorphous aragonite, which does not attach to the water supply pipes, nipples, prevents biocorrosion, the pipes do not calcify, and the previously formed lime scale is completely removed within 4–6 weeks. This device operates constantly (www.planethorizons.com).

The aim of our research was to investigate the impact of the water treated with the device AQUA 4DPRO60 on zootechnical parameters, the amount of blood serum major minerals and the indices of bone mineralization of broiler chickens.

Materials and Methods. The trial was carried out on the poultry farm JC Vilniaus Paukstynas and at the Research Laboratory of Biological Diversity and Technologies of Vilnius Pedagogical University. The trial was performed with 2 groups of one-day-old chickens; each group contained 27600 chickens. The first group was the control group, and the other one was the trial group. The broiler chickens of the trial group received feed of the same composition and nutritive value as the ones of the control group, but their drinking water was treated with the device AQUA 4DPRO60. The chickens were raised on deep litter from 1 to 36 days of age, and they received water from the stationary nipple drinkers. The chickens were fed ad libitum. Their keeping, feeding and care conditions in both groups were the same. Husbandry conditions for the chickens complied with good commercial practices and with the Law of the Republic of Lithuania on the Care, Keeping and Use of Animals as well as secondary legislation i. e. the Orders of the State Food and Veterinary Service of the Republic of Lithuania On Veterinary Regulations on Breeding, Handling and Transportation of Laboratory Animals and On the Use of Laboratory Animals in Scientific Experiments (Law of the Care, Welfare and Use of Animals, 2002).

During the trial the following indices were investigated: individual body weight of the chicken aged 1, 14, 28 and 35 days, the amount of the consumed feed in each group over 1–8, 9–21 and 22–36 days of age, liveability of chickens and the litter moisture. Litter moisture was determined by applying a weighing-drying method and using a moisture analyzer *KERN MRS 120-3*. At the end of the raising period, the blood of 17 birds, at slaughter, was collected into 7-ml centrifuge test-tubes which were centrifuged at 3 000 rpm for 15 minutes. Using a biochemical electrolyte analyzer *SPOTCHEM EL SE – 1520* macroelements Ca, P, Na, K and Cl from the separated blood serum were determined. In the *tibia* of the bird the amount of phosphorus and calcium was identified. A segment of the bone was extracted by using petroleum spirit, dried at 100°C for 4 hours and cindered at 550°C for 16 hours. The measurements of the total major minerals (per cent ash), Ca (per cent Ca) and P (per cent P) contents relative to the dry, fat-free weight of the bone sample were made, the latter two by spectrophotometry and colorimetry, respectively (Williams *et al.*, 2000). The data were analysed by ANOVA with the statistic software JMP (Version 5.1, SAS Institute). Differences between means were tested for significance by the Student's *t*-test.

Results and Discussion. The body weight of the

chickens which received water treated with electromagnetic vibrations at the investigated age periods was close to the weight of the chickens of the control group, and only at the end of the growth period, at the age of 35 days, the chickens of the trial group were by 68 g heavier than the ones of the control group ($p < 0.05$) (Table 1). According to the target growth curve Ross 308 birds at the age of 35 days have to weigh 1 882 g. A bigger body weight of the birds in the trial group determined during the investigations may be explained by the fact that their metabolism was more intense, and their feed conversion was better as they consumed less feed (Feddes *et al.*, 2002; Patterson *et al.*, 2003).

Liveability of birds in the trial group was by 1 per cent higher than in the control group.

The birds of the trial group which received drinking water treated with electromagnetic vibrations, consumed

less feed i.e. 1 910 g/bird, whereas the birds in the control group consumed 1 930 g/bird. The amount of the consumed water throughout the entire trial was respectively 3 364 ml/bird and 1.78 ml/g of the bird weight, and 3 187 ml/bird and 1.75 ml/g of the bird weight. These findings are consistent with the data obtained by other authors and they indicate that the birds consume more water in case of more intensive metabolism (Feddes *et al.*, 2002;). Birds consume water differently, and it is influenced by many factors: ambient temperature, age of a bird, stocking densities, and health (Feddes *et al.*, 2002; Manning, 2008; Oviedo and Gibson, 2006). The standard of a daily amount of water for chickens is about 200 ml per one kilogram of live weight. The increased or reduced water intake may be associated with the state of health of the bird (Manning, 2008) or water hardness (Mohammed, 2011).

Table 1. **Growth indices of broiler chickens**

Age of chickens, days	Control group	Trial group
	Weight of a chicken, g	
1	42.05±0.35	43.0±0.30
14	421.0±0.60	422.0±0.70
28	1350.0±7.24	1320.0±6.50
35	1820.0±13.56	1888.0±76.32*
Liveability, %		
1–8	99.08	99.05
9–21	98.40	98.10
22–35	97.85	97.02
1–35	94.10	95.10
Feed consumption, 1 kg increase in weight, kg		
1–35	1.930±0.090	1.910±0.200
Water consumption, ml		
1–35	3 187	3 364*
Litter moisture, %		
1–35	43.78	37.55*

*The data are statistically reliable ($p < 0.05$)

Having analyzed the litter moisture during the entire trial period, it was determined that in the control group it was damper by 6.23 per cent ($p < 0.05$). In poultry farming the greatest attention is given to ammonia as it is the main air polluter because its emission is the greatest one. It is supposed that the techniques for the reduction of ammonia emission will enable to reduce the amounts of emission of other gaseous substances (EP and Council Directive, 1996; Sharpley, 1999). The drier the litter, the smaller amount of ammonia is released into the environment. Drier litter indicates that fewer birds get diarrhoea, they are healthier and it means that their digestion is better (Ghadban, 2002; Nahm, 2003; Smith *et al.*, 2000).

At the end of the trial, major minerals in the blood serum of chickens were within the physiological limits, although the amount of Cl was by 3.9 per cent higher ($p < 0.05$) in the trial group, compared with birds of the control group (Table 2). Cl affects digestion because proteolytic enzyme pepsin of glandular stomach actively oper-

ates only in acidic environment created by the HCl, then feed proteins are better dissociated, more intensive synthesis of proteins takes place in the birds and their weight increases (Ahmad, 2004). This is confirmed by our obtained data of the bird weight in the trial group.

The amount of phosphorus in the blood serum (Orban *et al.*, 1999) and in tibia ash (Mohammed, 2011; Philips, 1998) indicates that broiler chickens assimilated phosphorus better. When the concentration of phosphorus in blood serum decreases, it is mobilized from the bones, and when it increases it is deposited in them. If there is an increase in the amount of calcium in the chicken blood serum and bone tissue, it may be supposed that calcium is assimilated more intensively.

The observed amount of phosphorus and calcium in tibia of chickens in the trial group was higher than in the control group ($p > 0.05$) (Table 3). Our data coincided with those of other authors (Moreti, 2005; Rama Rao *et al.*, 1999).

Table 2. The parameter of blood serum major minerals of chickens at the age of 35 days

Investigations	Control group	Trial group
Ca, mmol/l	3.05±0.040	3.06±0.050
P, mmol/l	2.37±0.070	2.40±0.120
Na, mmol/l	146.86±1.829	152.86±1.148
K, mmol/l	6.31±0.090	6.49±0.063
Cl, mmol/l	115.57±0.684	120.00±0.833

Table 3. The amount of phosphorus and calcium in tibia of chickens at the age of 35 days

Investigations	Control group	Trial group
P, %	6.11±0.121	6.42±0.310
Ca, %	20.42±0.635	21.18±0.760

Conclusions

Summarizing the results of our performed investigations, it is possible to state that water treated with the device AQUA 4DPRO60 and used as a drinking water for chickens induces the growth of birds, favourably effects digestion of birds, their liveability, and improves microclimate in the poultry house because it significantly decreases the litter moisture. The analysed amounts of major minerals in the blood serum of birds were within the physiological limits, and the water treated with electromagnetic vibrations did not have a crucial impact on these parameters. The studied amount of phosphorus and calcium in tibia of chickens in the trial group was higher in comparison with the control group.

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