HEALTH INDICATORS OF THE POULTRY DRINKING WATER TREATED WITH ELECTROMAGNETIC VIBRATIONS

Rasa Bobinienė[1], Manefa Miškinienė[2], Diana Gudavičiūtė[1], Zygmunt Mackiewicz[3]

[1]Biologically Active Substance Research Laboratory of Institute for Scientific Research
Lithuanian University of Educational Sciences
Studentų 39, Vilnius LT-08106; Phone: (8-5) 275 70 95; E-mail: bamlab@leu.lt.
[2]Department of Technology and Technological Education, Lithuanian University of Educational Sciences
Studentų 39, Vilnius LT-08106; Phone: (8-5) 275 32 25; E-mail: technologinis.ugdymas@leu.lt.
[3]State Research Institute Center for Innovative Medicine
Žygimantų 9, LT-01102, Vilnius; E-mail: zmzmackiewicz@gmail.com

Abstract. Water is an important factor in poultry raising; therefore, both quantitative and qualitative analysis of water should be performed on a regular basis. Water treatment on poultry farms has been gaining greater popularity in Europe. A physical method developed by Swiss researchers is based on treating water with electromagnetic vibrations and thus influencing various processes taking place in the water, and first of all, removing a biofilm i. e. reducing pathogenic microflora in water and potentially demising water-borne infections. The researches were performed at the Research Laboratory of Biologically Active Substances of Lithuanian University of Educational Sciences and on the farmer's V. Rimša farm. For the trial 2 groups, each one containing 32 000 day-old ROSS-308 cross chickens, were formed. The first group (n=32 000) was a control group, and the other one was a trial group (n=32 000). The broiler chickens of the trial group received feed of the same composition and nutritional value as the chickens of the control group, only their drinking water was treated with electromagnetic vibrations which structurize water and destroy a biofilm in water supply pipelines. Using water treated with electromagnetic vibrations for watering birds, the performance and health of chickens may be improved: the measured mass of chickens of the trial group was bigger by 17.60 per cent ($p < 0.05$), due to the enhanced feed conversion, the amount of consumed water in the trial group was bigger by 5. 28 per cent, better histological indicators of duodenum were obtained in the trial group, mortality of the chickens of the trial group was lower by 2.61 per cent. Litter moisture decreased twice ($p < 0.05$), and as a result, microclimate of the poultry house improved.
Keywords: chickens, drinking water treated with electromagnetic vibrations, litter moisture, histology, mortality.

Introduction

It was established that water is an important factor in poultry raising because a bird can survive several weeks without food, but only a few days without water. Broilers drink a great deal of water and a critical fact that producers may not be aware of is that feed and water consumption are very closely related (Tabler, 2003), for example, a 2.3 kg broiler will consume about 8.2 kg of water, compared to approximately 4.6 kg of feed (Lacy, 2002). Knowing the volume of water consumed, it is possible to establish the amount of feed consumed daily (Lott et al., 1992). B. D. Lott et al. (2003) estimated the correlation between feed and water consumption at 0.98. In short, this means that when water consumption changes, in 98 % of the cases feed consumption changes as well. Because of this fact, daily feed consumptio can be easily estabished by accurate monitoring of daily water consumption. Monitoring water consumption on a daily basis has been shown to be a reliable measure of broiler performance (Defra, 2002). Therefore, both quantitative and qualitative analysis of water should be performed on a regular basis because that affects health and welfare of birds (Alleman and Leclercq, 1997; Zimmerman and Douglass, 1998). Water consumption both during a day and during the entire raising period is a key indicator reflecting the state of the birds' health. The correlation between the total amount of water consumed, mortality rate and frequency of enteritis has been established (Manning, 2007).

Water, in addition to being a vital nutrient, is involved in many aspects of poultry metabolism including body temperature control, digestion and absorption of food, transport of nutrients, and the elimination of water products, via urine, from the body (Jafari et. al., 2006). It is an |accepted practice to monitor daily the birds' water consumption by poultry house as it can often be an early indication of a health problem as the water consumption may either increase or decrease compared to the standard consumption expected (Defra, 2002; Butcher et al., 1999). Water consumption can be affected by a number of interacting parameters: birds, water quality, feed quality and poultry house environmental issues (Manning, 2007).

Air humidity is a key factor in determining air quality (Francesch and Brufau, 2004; Algers and Svenberg, 1989). The factors which impact air humidity of a poultry house include: external air humidity, type and management of a drinker system, water consumption, age and weight of birds, temperature profile (Scahaw, 2000; Broadbent and Pattison, 2003).

Poor control of moisture in the poultry house environment can lead to health and welfare issues including contact dermatitis, enteritis and respiratory diseases if ammonia concentrations in the air exceed certain levels (Ekstrand, 1993). If the litter is drier, the emission of ammonia into the environment is lower (Ferguson et al., 1998). Control of litter quality may help to avoid environmental and animal welfare problems and may increase economic profits in commercial poultry industry. Control of excreta/litter quality implies reduction of their amounts and moisture. Feeding factors may also affect water consumption and its excretion with faeces (Francesch M. and Brufau J., 2004).

The researches have demonstrated that one of the most common causes of enteritis is a biofilm in water supply pipelines and accumulation of the multiplying microorganisms located in it (Jafari et al., 2006). For this reason, the increased levels of intestinal bacteria are related with the increase of intestinal weight. The gut flora, then, promote thickening of the intestinal mucosa which reduces its absorptive capacity. Germ-free animals have thinner intestinal walls than their conventional equivalents (Abrams et al., 1963). This is partly due to a decrease in lymphoid tissue in the *lamina propria* (Stutz et.al., 1983), which results from a decrease in antigenic stimulation of the mucosa (Gaskins, 1996).

Water treatment and sanitisation programmes are an important control measure to minimise bacterial contamination of water systems and minimise the accumulation of biofilms (Vanjari et al., 2008; Watkins, 2006).Water treatment on poultry farms has been gaining greater popularity in Europe (Pattison, 2001). A physical method developed by Swiss researchers is based on treating water with electromagnetic vibrations and thus influencing various processes taking place in the water, and first of all, removing a biofilm i. e. reducing the amount of pathogenic microflora in water and thus potentially diminishing water-borne infections (PHT: Water treatment for livestock, 2012).

All the above mentioned factors enable to substantiate the importance of the qualitative drinking water to the health of birds. Despite the researches carried out in this field worldwide (Watkins, 2006; Pattison, 2001; Zimmerman and Douglass, 1998), the issues regarding the influence of water quality on the health of birds have not yet been researched sufficiently in Lithuania. Therefore, **the goal of our study** was to investigate these health indicators: mass, histological indices of duodenum, mortality, dynamics of water consumption of chickens, litter moisture, air temperature and relative humidity in the poultry house, when the birds received water treated with electromagnetic vibrations.

Materials and methods

The researches were performed at the Research Laboratory of Biologically Active Substances of Lithuanian University of Educational Sciences and on the farmer's V. Rimša farm. For the trial, 2 groups, each one containing 32.000 day-old ROSS-308 cross chickens, were formed. The first group was a control group, and the other one was a trial group. The broiler chickens of the trial group received standard feed of the same composition and nutritional value as the chickens of the control group, only their drinking water was treated with the device AQUA 4DPRO60, which structurizes water and destroys a biofilm in water supply pipelines by electromagnetic vibrations (PHT: Water treatment for livestock, 2012).

The birds were raised on deep litter from 1 to 36 days of age and received water from stationary nipple drinkers. The chickens were fed *ad libitum*. Housing, feeding and managing conditions of chickens in both groups were the same. Husbandry conditions for chickens were complying 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 – Order 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 researched: weight of birds, the amount of water consumed every day and during the raising periods of 1–8, 9–21, 22–35 and 1–35 days; the amount of feed was calculated every day and throughout the entire rearing period; mortality of birds was identified every day; litter moisture was measured throughout the entire trial period; air temperature and relative humidity in the poultry house were measured a daily basis.

The birds were weighed on a regular basis with the stationary computerized Roxell scales equipped in the poultry house, which allow observing the growth of chickens in a detailed and precise manner.

Litter moisture was estimated with the moisture meter KERN MRS 120-3.

Air temperature and relative humidity were measured continuously using the computerized Roxell climate management system.

During post-mortem inspection performed at the end of the trial, 6 duodenal samples were taken for histological examination (3 samples were taken from the birds of the control group, and 3 samples were taken from the birds of the trial group). Segments from the middle of the duodenum 0.5 mm length were excised, opened longitudinally and fixed in 10 % neutral buffered formalin for 24 h at 4°C. Then they were rinsed in water, dehydrated in ethanol and embedded in paraffin. Deparaffinised 4µm sections were stained with haematoxylin and eosin and analysed in the microscope Olympus BX51 fitted with Nikon Digital camera DXM1200 and Digital analysis program.

The data was processed by applying statistical biometry methods and using Statistica for Windows, Version 6.0 (StatSoft Inc.). The results are considered reliable when $P<0.05$.

Results and discussion

The chickens of the trial group which received water treated with electromagnetic vibrations drank more water than the chickens of the control group (Table 1). The amount of water drunk by one chicken during separate periods was also higher compared to the control group. It was observed that the amount of water consumed by birds closely correlates with feed consumption because when water consumption changes, feed consumption changes as well (Lott et al., 2003).

Table 1. **Dynamics of water consumption by chickens**

Age of chickens in days	Control group		Trial group	
	Total water consumption, litres	Water consumption by one chicken, litres	Total water consumption, litres	Water consumption by one chicken, litres
1–35	179775	7.01	165100	7.38
1–8	10700	0.35	4344	0.37
9–21	64018	1.61	51956	1.67
22–35	105057	5.05	108800	5.34

During the entire period of the trail, one bird of the trial group drank 7.38 kg of water and consumed 4.3 kg feed on an average, and the average bird weight at the end of the trial was 2.40 kg, whereas one bird of the control group drank 7.01 kg of water and consumed 3.82 kg of feed during the entire rearing period, and at the end of the trial period one chicken weighed 1.98 kg on an average. The data of chicken mass were statistically reliable ($P<0.05$) (Table 2).

Table 2. **Dynamics of mass growth of chickens when they receive water treated with electromagnetic vibrations**

Age of chickens in days	Control group	Trial group
Mass of chickens, g		
1-35	1980±23.45*	2403±25.22*
1-8	180±5.10	188±6.62
9-21	920±10.54	912±12.45
22-35	1960±21.73	2000±22.19
*P<0.05		

According to the target growth curve (Ross Breeders, 1999), weight of a 35-day-old chicken should be 2250 g. During our research the estimated bigger weight of the chickens in the trial group may be explained by the fact that the birds drank more water, consumed more feed, and feed assimilation was much better. These data coincide with the ones of other authors that in case of more intensive metabolism, birds drink more water (Alleman and Leclercq, 1997). The amount of water consumed by birds correlates with the temperature of the poultry house as well: the higher the temperature, the more water is drunk by the chickens (May, 2000). In our trial, the temperature of the poultry house of the trial group did not differ from the temperature of the poultry house of the control group. According to the results obtained during our research, we can state that mortality of birds in the trial group was also lower by 2.61 per cent. Performing analysis of litter moisture during the entire period of the trial it was established that it was wetter by 25.3 per cent in the control group. The data are statistically reliable. Air humidity in the control group was also higher by 8.0 per cent than in the trial group (Table 3).

Table 3. **Changes of temperature and relative humidity of the poultry house when chickens receive water treated with electromagnetic vibrations**

Indices	Age of chickens in days			
	1-35	1-8	9-21	22-35
	Control group			
Temperature in the poultry house, °C	25	30	25	21
Relative humidity in the poultry house, %	68	68	67	70
Litter moisture, %	56.52*			
	Trial group			
Temperature in the poultry house, °C	25	30	25	21
Relative humidity in the poultry house, %	60	60	61	60
Litter moisture, %	31.22*			
*P<0.05				

Many poultry growers underestimate the negative impact of ammonia. Birds are particularly sensitive to ammonia levels. Long-term high concentrations of ammonia levels can cause blindness in chickens; and consequently, their performance decreases. It is ideal to maintain litter moisture at approximately 25 per cent (Ritc, 2010). The drier the litter, the less ammonia is released into the environment (Ferguson et al., 1998). Drier litter indicates that birds have fewer diarrhea cases, they are healthier, and it means that their digestion improves (Algers and Svenberg, 1989; Ouart et al., 1995).

At the end of the trial, duodenum of chickens was examined histologically. In the small intestine nutrients are digested till the final degradation products, which are resorbed into blood and lymph through the striated edge of columnar epitheliocytes of intestinal villi**.** The resorbing surface of the small intestine is increased by the macroscopic circular mucosal folds (*plicae circularis*), intestinal villi (*villi intestinales*) and microvilli of columnar epitheliocytes of intestinal villi**.** Histological structure of duodenum of chickens of the trial and the control groups is presented in Figs 1, 2, 3, 4, and 5. Histological examination of the duodenum showed that histological structure of duodenum of chickens of the trial group was without any pathological changes (Fig. 1). Muscular layer is about 340 µm, depth of mucosal folds is 180 µm, and its width is 50 µm.

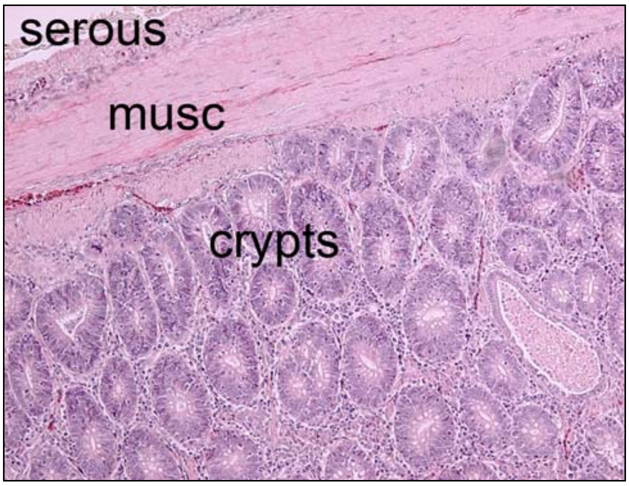

Fig. 1. **Duodenum. Normal structure**. Stained with haematoxylin and eosin. Original magnification x100.

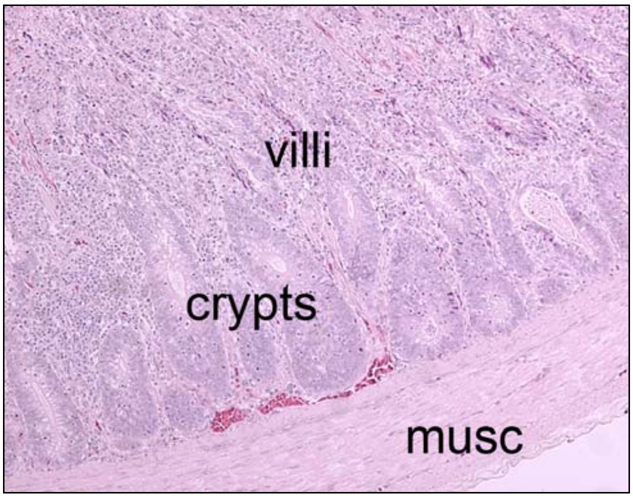

Fig. 2. **Duodenum. Normal structure. High villi.** Stained with haematoxylin and eosin. Original magnification x100.

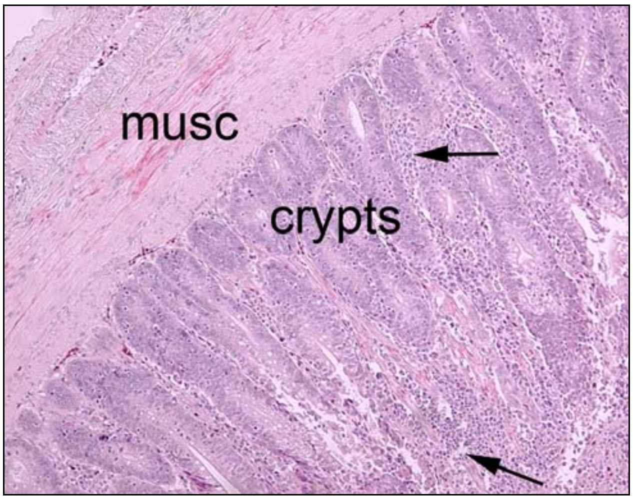

Fig. 3. **Duodenum. The arrows indicate lymphocytic infiltration.** Stained with haematoxylin and eosin. Original magnification x100.

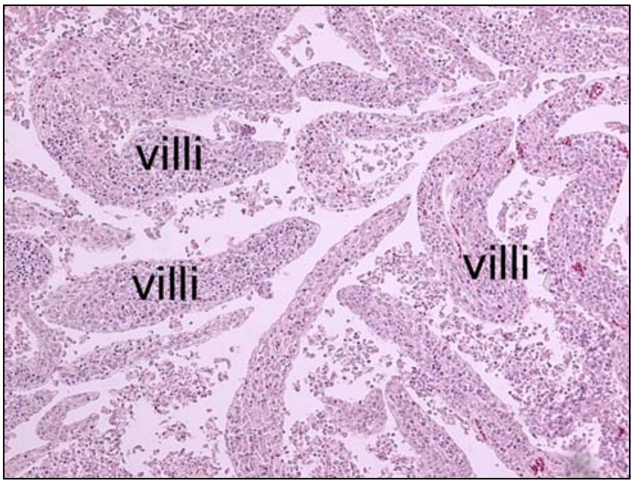

Fig. 4. **Duodenum. High thin villi.** Stained with haematoxylin and eosin. Original magnification x100.

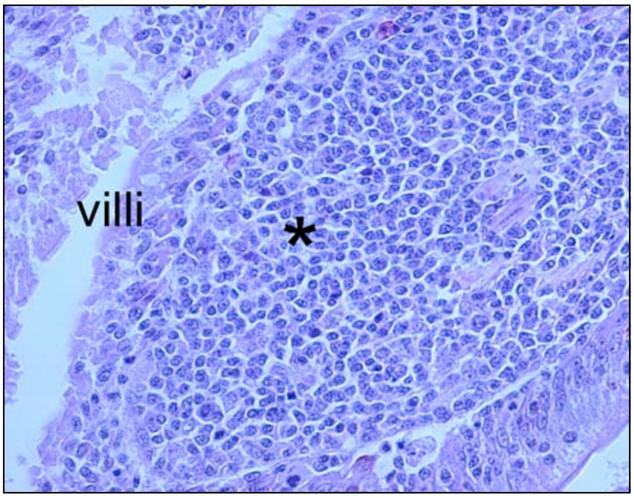

Fig. 5. **Duodenum. Villus. The asterisk indicates intravillous lymphocyte infiltration.** Stained with haematoxylin and eosin. Original magnification x100.

High intestinal villi (*villi intestinalis*) (Fig. 2) are seen, the height of intestinal villi of duodenum is about 1350-1430 μm, and the width is 660 μm. Villi are a key organ for nutrients resorption. The cells of immune response around the crypts and villi are not seen or are few and scattered. Columnar epitheliocytes and goblet exocrinocytes of the villi are seen in mucosal epithelium. A muscle layer of mucosa consisting of smooth myocytes is clearly seen.

In the histological section of duodenum of the chickens in the control group more intense lymphocytic infiltration is seen around the crypts (Fig. 3).

Histological structure of duodenum of chickens in the control group has slightly changed, thin and less high intestinal villi are seen in it, and it differs from the one of the chickens in the trial group (Fig. 4). Reduction in villus height and crypt depth has been reported in poultry with small intestinal bacterial overgrowth (Toskes et al., 1975) suggesting that certain gut microbes may damage enterocytes directly in this context. In the control group, intravillous lymphocytic infiltration was more intense than in the treated group (Fig. 5).

The place marked with the asterisk indicates intravillous lymphocytic infiltration (Fig. 5).

The results of our researches are similar to the results obtained by the scientists of other countries (Gabriel, I., S. Mallet Lessire M. and Guillot JF, 2006). According to the literature data, water of good quality and structure improves digestion of birds (Manning, 2007; Gabriel et al., 2006). This is also confirmed by our histological analysis of chickens' duodenum.

Conclusions

To sum up the results of the researches performed, it is possible to state that using water treated with electromagnetic vibrations for watering birds, the performance and health of chickens may be improved. This is demonstrated by the following indicators:

- the measured mass of chickens of the trial group was bigger by 17.60 per cent ($P<0.05$);
- better histological indicators of duodenum were obtained in the trial group (villi intestinalis are high, the cells of immune response in the preparation around the crypts and villi are not seen);
- due to the enhanced feed conversion, the amount of consumed water in the trial group was bigger by 5. 28 per cent;
- at the end of the trial litter moisture in the trial group of chickens was lower by 25.30 per cent ($P<0.05$);
- relative air humidity in the trial group was lower by 8.0 per cent;
- mortality of the chickens of the trial group was lower by 2.61 per cent.

References

1. Abrams G.D., Bauer H. and Sprintz H. Influence of the normal flora on mucosal morphology and cellular renewal. A comparison of germ-free and conventional mice. Laboratory Investigation. 1963. 12. P. 355–364.

2. Algers B. and Svenberg J. Effects of atmospheric ammonia and litter status on broiler health. Proceedings 3rd European Symposium On Poultry Welfare, Tours. 1989. P. 237–241.

3. Alleman F. and Leclercq B. Effect of dietary protein and environmental temperature on growth performance and water consumption of male broiler chickens. British Poultry Science. 1997. 38. P. 607–610.

4. Broadbent L. and Pattison M. Winter Ventilation - Minimum Ventilation for Good Air Quality. Poultry World, November. 2003.

5. DEFRA. Meat Chickens and Breeding Chickens.Code of recommendations for the welfare of livestock, PB7275. 2002.

6. Ekstrand C. Effects of stocking density on the Health, Behaviour and Productivity of Broilers. Swedish Facility of Agricultural Science Report 32. Skara.1993.

7. Ferguson N.S., Gates R.S., Taraba J.L., Cantor A.H., Pescatore A.J.,Ford M.J. and Burnham D.J. The effect of dietary crude protine on growth, ammonia concentration, and litter composition in broilers. Poultry Science. 1998. 77. P.481–1487.

8. Francesh M. and Brufau J. 2004. Nutritional factors affecting exreta/litter mousture and quality. World's Poultry Science. 2004. 60. P.64–75.

9. Gabriel I., Lessire M., Mallet S. and Guillot J.F. Microflora of the digestive tract: critical factors and consequences for poultry. World's Poultry Science Journal. 2006..62. P. 499–511.

10. Gaskins H.R. Immunological aspects of host/microbiota interactions at the intestinal epithelium. Gastrointestinal Microbiology. 1996. 2. P. 537–587.

11. Jafari R.A., Fazlara A. and Govahi M. An investigation into *Salmonella* and faecal coliform contamination of drinking water in broiler farms in Iran. International Journal of Poultry Science. 2006. 5. P. 491–493.

12. Lacy M. P. Broiler management. In : Commercial Chicken Meat and Egg Production (D.B. Bell and W.D. Weaver, Eds.) 5th Ed. 2002. P. 829–868.

13. Lott B.D., Dozier W.A., Simons J.D. and Roush W.B. Water flow rates in commercial broiler houses. Poultry Science. 2003.82 (Suppl.1): 102. P. 56.

14. Lott B.D., Simmons J.D. and May J.D. An automated feed and water consumption measuring system for poultry research. Appl. Eng.Agric. 1992. 8. P. 521–523.

15. May J.D., Lott B.D. and Simmons J.D. The effect of air velocity on broiler performance and feed and water consumption. Poultry Science. 2000. 79. P. 396–1400.

16. Manning L., Chadd S.A. and Baines R.N. Key health and welfare indicators for broilers production. World's Poultry Science Journal. 2007. 63. P.47–62.

17. Ouart M.D., Damron B.L. and Christmas R.B. Effect of coccidiostats on performance, water intake, and litter moisture of broiler chicks. Journal of Applied Poultry Research. 1995. 4. P. 374–378.

18. Pattison M. Practical intervention strategies for *Campylobacter*. Journal of Applied Microbiology. 2001. 90. P. 121–125.

19. PHT: Water treatment for livestock (Available at: http://www.planethorizons.com. on 11 September 2012)

20. Ritc K.U. Quality of litter and broiler productivity. Zootecnica International. 2010. 6. P. 26–37.

21. Ross Broiler Management Manual. Ross Breeders, November. 1999.

22. Scahaw. European Commission – Scientific Commitee on Animal Health and Welfare 2000. The Welfare of Chickens Kept for Meat Production (Broilers) European Commission, Brussels, Belgium Adopted 21 March 2000.

23. Stutz M.W. and Lawton G.C. Effects of diet and antimicrobials on growth, feed efficiency, intestinal *Clostridium perfringens*, and ideal weight of boiler chicks. Poultry Science. 1984. 63. P. 2036–2042.

24. Tabler G. T. Water Intake: A Good Measure of Broiler Performance. Avian Advice. 2003. 5(3). P. 7–9.

25. Toskes P.P., Giannella R.A., Jervis H.R., Rout W.R. and Takeuchi, A. Small intestinal mucosal injury in the experimental blind loop syndrome; light and electronmicroscopic and histochemical studies. Gastroenterology. 1975. 68. P. 1193–1203.

26. Vanjari S.S., Kalorey D.R., Dhamannapatil P.S., Dhanawade N.B., Shinde R.S., Sable U.P., Chavhan S.K. and Nagdive A.A. Biofilm production in *Escherichia coli*: A global problem in poultry industry. World's Poltry Science Journal. 2008. Suppl. 2. P. 647.

27. Watkins S.E. Water quality and sanitation. Poultry Digest Online. 2006. 3(12). The paper was presented at the 2003 U.S Poultry& Egg Association Poultry Production and Health Seminar. Accessible at www.wattnet.com/library/SownLoad/PD 12 waterq.pdf.

28. Zimmerman N.G. and Douglass L. A survey of drinking water quality and its effect on broiler growth performance on Delmarva. Poultry Science. 1998. 77 (Suppl.). P. 121.

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