# THE INFLUENCE OF WATER TREATED WITH ELECTROMAGNETIC VIBRATIONS ON WATER CONSUMPTION, GROWTH OF BROILER CHICKENS AND QUALITY INDICATORS OF THE MEAT

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**Abstract.** Effect of the water treated with electromagnetic vibrations on the broiler chicken's water consumption, growth of broiler chickens and quality indicators of the meat was investigated.

The broilers in both groups were fed at libitum with granulated the standard feed of the same composition and the same nutritional value, except the addition of the water treated with electromagnetic vibrations for trial group. Feed and water consumption is the major factor that influences both the body weight gain and feed conversion in meat-type poultry, had a positive impact on the chemical composition of meat and carcass of meat. In the trial group, the amount of dry matter ($P<0.05$) and protein ($P<0.05$) in broiler chickens' meat was larger. Most significant increase was determined on carcass yield ($P<0.05$), the weight of edible parts ($P<0.05$) and muscle weight ($P<0.01$). Water consumption in the trial group both in separate rearing periods and during the entire rearing period was larger compared with the control group, and that could be related with more intensive growth of chickens and better liveability. Water treated with electromagnetic vibrations did not have any influence on histology of broiler's skeletal muscles.

**Keywords:** chickens, growth, water consumption, meat, carcass.

**Introduction.** Poultry meat production and consumption have increased rapidly, and in many parts of the world per capita consumption of poultry meat is going to continue to grow (Cavani *et al*., 2009), therefore meat quality and chemical composition of the meat have become a major concern for poultry market. Meat quality is influenced by a number of internal and external factors. The histochemical and biochemical characteristics of skeletal muscles are primarily the result of genetic and environmental factors (gender, muscle type, nutrition, breed, hormones, growth promoters, stress) (Petracci and Cavani, 2012).

Current cross broiler chickens are characterized by a considerable genetic potential for chicken growth and efficient feed conversion (Fisinin and Surai, 2012). To achieve their genetic potential for growth, broilers must be provided with optimal environmental conditions. Any deviation from optimal conditions can result in decreased performance (Feddes *et al.*, 2002). The nutritional level of the diet is the major environmental factor in commercial production. It must be optimized for a broiler to achieve its maximum genetic potential for meat production and growth rate (Marks, 1993). Rearing broiler chickens, the first week of their rearing is crucial and has the greatest impact on their successful growth. (Tumova and Teimouri, 2009). In fast-growing commercial strains of broilers and ducks, the first 7 days represent approximately 17% of the rearing period from an age standpoint (40 days) and 8 to 10% of the rearing period with respect to percentage of the final body weight (Lilburn, 1998; Ncube *et al*., 2012).

In poultry industry, there is a strong relationship between feed and water consumption, therefore water consumption can be used for monitoring flock performance. Water consumption is an indicator demonstrating the bird's condition. (Manning *et al.,* 2007). A potential problem may exist if there is a sudden change in water intake (Fairchild and Ritz, 2006). Low water intake results in low food intake, reducing the availability of water and nutrients required by biochemical and physiological function that are essential for body homeostasis and growth (Gomes *et al*., 2008). During the stress feed consumption often reduces, whereas water consumption increases 1.6-2.0 times (Fairchild and Ritz, 2006; Virden *et al.* 2009; Ferket and Gernat, 2006). During the heat stress water consumption increases from two to four times. A safe and adequate supply of water is therefore essential for efficient poultry production (Carter and Sneed, 1998).

Poor water quality may interfere with digestion and subsequent bird performance. The efficacy of vaccines and medicinal products administered through the water lines could be reduced when water quality is poor. Moreover, water contaminants could cause equipment problems that would either restrict the amount of water available for consumption or harm the effectiveness of the evaporative cooling and fogging systems. Reduced water consumption or cooling capacity may have detrimental effects on both growth and reproduction. Poor water quality used for bird consumption influences the moisture of the litter (Patterson *et al.,* 1998).

Poor water quality could also result in leaky water nipples inside the house, which will wet litter and lead to the increased ammonia production. Poor litter quality and high ammonia can result in reduced performance and liveability (Fairchild and Ritz, 2006). Water used on bird farms usually contains a large amount of lime and iron and is the cause of blockage of nipples; consequently, birds do not receive the required amount of water (Ferket and Gernat, 2006). High levels of iron may promote the growth of bacteria, which can lead to diarrhoea in poultry (Blake and Hess, 2001). Calcium and magnesium salts have influence on hardness of water and may cause the formation and accumulation of residues in water lines and the formation of biofilm in the pipelines. Biofilm is a serious threat to decrease the production as well as increase the onset of diseases (Barton, 1996). Moreover, efficacy of vaccines and medicinal products when used with water may reduce if the water is hard (PHT: Water treatment for livestock, 2012; Blake and Hess, 2001).

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). 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. High quality water is an indisputable condition for the growth of broiler chickens and performance. The treatment is ecological as no chemical product are used, and it does not change chemical composition of the water (https://www.aqua4d.com/_2017).

This study was carried out in order to research the impact of water treated with electromagnetic vibrations on the water consumption, growth of broiler chickens and quality indicators of the meat.

**Materials and methods**

The studies were carried out on 32.000 day-old ROSS-308 cross broiler chickens, which were divided into two groups. The birds were raised on deep litter from 1 to 35 days of age and received water from stationary watering equipment from the first day of age till the age of 35 days ad libitum. The broiler chickens were fed ad libitum with a granulated standard feed in both groups. The feed met the nutrient and energy requirement for Ross broiler chickens (Ross 308 Broiler Performance Objectives, 2012). Two months before the beginning of the trial, in the poultry houses of the trial group the equipment Aqua-4D®, which structures water and destroys a biofilm in water supply pipelines by electromagnetic vibrations, was mounted (PHT: Water treatment for livestock, 2012). Other housing, feeding and managing conditions of broiler chickens in both groups were the same.

The scientific research was conducted following the provisions of the Law of the Republic of Lithuania (2012-10-03) on the Care, Keeping and Use of Animals No. XI – 2271. The research was carried out in accordance with EU Directive 2010/63/EC and the EC recommendation 2007/526 EC for Animal use and storage for experiments and other purposes.

For chemical and bacteriological studies, water samples were taken from the poultry houses of both groups and the following was defined: total water hardness according to LST EN ISO 14911:2000; total iron according to LST ISO 6332:1995; concentration of hydrogen ions was determined according to LST EN ISO 10523:2012; a number of microorganism colony forming units at 22$^{o}$C was determined according to LST EN ISO 6222:2001; intestinal cells (*Escherichia coli*) and coliform bacteria were determined according to LST EN ISO 9308-1:2014; intestinal enterococci were determined according to LST EN ISO 7899-2:2001.

During the trial the following indices were researched: weight of birds, the amount of water consumed every day and during the rearing periods of 1 – 8, 9 – 21, 22 – 35 and 1 – 35 days; the amount of consumed feed was calculated every day and throughout the entire rearing period. The birds were weighed on a regular basis with the stationary computerized Roxell scales equipped in the poultry house.

For the analysis of chemical composition of post-mortem breast muscle meat 5 samples have been taken from both groups of the age of 35 days. Content of dry matter, protein, fat, ash was determined by AOAC (1990). The amount of dry matter was measured by the automatic scale for humidity assessment KERN MRS – MRS – 3, drying samples at the temperature of 105 ºC, intramuscular fat – by an automatic system for fat extraction Soxhlet SE 416 macro (ISO 1443:1973 Meat and meat products determination of total fat content), protein amount - according to Kjeldal method, total ash – by organic matter incineration at the temperature of 700 ºC (ISO 936:1998 Meat and meat products determination of total ash).

Dissection of carcasses was carried out according to Marche (2000). Breast muscle pH was recorded at 1 h (pH1h), 24 h (pH24h) post-mortem using a portable HI 9625 pH meter (Hanna Instruments, Italy).

During post-mortem inspection performed at the end of the trial 6 breast muscle samples were taken for histological examination. Segments from the middle of the breast muscle 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 4 µm 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 were 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**

According to the data of our research in the trial group, treatment of water with electromagnetic vibrations did not have crucial influence on chemical indices of water; however bacteriological indices were better in the trial group (Table 1).

The weight of broiler chickens of the trial was significantly larger during the researched periods (Table 2). The measured weight of chickens of the trial group at the age of 8 days was larger by 6.48 per cent ($P<0.01$) and at the age of 35 days it was larger by 6.78 per cent ($P<0.01$). According to the target growth curve (Ross 308 Broiler Performance Objectives, 2012) weight of a 35-day-old chicken should be 2250 g. We see the potential to improve the daily weight gain and feed conversion. In our study bird liveability was 95 % in the control group and 97 % in the trial group.

During our research the estimated larger weight of the broiler 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 (Alleman and Leclercq, 1997, Ferket and Gernat, 2006) that in case of more intensive metabolism and stress, birds drink more water.

Table 1. **Indices of chemical and bacteriological research of the water**

| Analyte | Control group | Trial group |
|---|---|---|
| | Result of the research, measurement units | |
| Total water hardness | 2.35 mmol/l | 2.34 mmol/l |
| Total iron | 0.036 mg/l | 0.018 mg/l |
| Concentration of hydrogen ions | 7.8 | 7.7 |
| A number of microorganism colony forming units at 22 C | $4.3x10^1$/ml | $1.8x10^1$/ml |
| Intestinal cell | 100 ml – negative | 100 ml – negative |
| Intestinal enterococci | 3 KSV/100 ml | 100 ml – negative |
| Coliform bacteria | 2 KSV/100 ml | 100 ml – negative |

Table 2. **Growth indices of broiler chickens**

| Age of chickens, days | Control group | Trial group | Probability |
|---|---|---|---|
| Weight of chickens, g | | | |
| 1 | 42.0±0.28 | 41.05±0.30 | NS |
| 8 | 216±3.19 | 230±8.24 | ** |
| 21 | 920±10.54 | 929±11.65 | NS |
| 35 | 2093.12±19.15 | 2235.02±21.22 | ** |
| **The data are statistically reliable (P<0.01) | | | |

Water consumption in the trial group both in separate rearing periods and during the entire rearing period was larger compared with the control group (Table 3). Actual water consumption relative to feed intake varies depending environmental temperature and dietary factors. It has been 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 3. **Dynamics of water consumption by broiler 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 | 105643 | 4.49 | 108681 | 4.72 |
| 1-8 | 6520 | 0.40 | 6810 | 0.45 |
| 9-21 | 34490 | 1.33 | 36489 | 1.42 |
| 22-35 | 62634 | 2.67 | 67381 | 2.94 |

During the entire period of the trail one bird of the trial group drank 4.72 kg of water, and the average bird weight at the end of the trial was 2.23 kg, whereas one bird of the control group drank 4.49 kg of water and at the end of the trial period one chicken weighed 2.09 kg on an average. The data of chicken weight were statistically reliable (P<0.01) (Table 2). The dissection data of chemical composition of broilers breast muscle submitted in Table 4 indicate that in the trial group the amount of dry matter and protein was larger. In the breast muscle of the chickens from the trial group there were more dry matter (by 1.52 %; P<0.05), protein (by 1.21 %; P<0.05) and by 0.38 % less fat, compared with of the control group.

Table 4. **The content of dry matter, protein, fat, ash of the broiler chickens meat at the age of 35 days**

| Indices | Control group | Trial group | Probability |
|---|---|---|---|
| Dry matter % | 23.88±0.152 | 25.40±0.158 | * |
| Protein % | 15.90±0.134 | 17.11±0.128 | * |
| Fat % | 3.05±0.07 | 2.67±0.09 | NS |
| Ash % | 1.26±0.02 | 1.81±0.03 | NS |
| The data are statistically reliable: * (P<0.05) | | | |

Water treated with electromagnetic vibrations had an impact on the increase of the amount of ash in the breast muscle of the broiler chickens of the trial group. In comparison with the control group, it was larger by 0.55 % (Table 4). That coincides with the data of other authors (Mazzoni *et al*., 2015).

The quality and composition of poultry meat are influenced by numerous factors such as genotype, gender, age, diet, rearing conditions, and preslaughter treatment of birds (Fletcher, 2002). The breast musculature is very developed in poultry, reaching 22-25 % of the whole carcass weight, and that is influenced by species, breed, hybrid and gender (Teusan *et al*., 2009).

The dissection data of the carcasses of the broiler chickens at the age of 35 days indicated that water treated with electromagnetic vibrations had a positive impact on qualitative indices of the broilers meat (Table 5). Due to water treated with electromagnetic vibrations, the carcass weight of broilers increased by 1.19 %, ($P < 0.05$), the weight of edible parts was larger by 3.0 % ($P < 0.05$), and the muscle weight increased by 3.15 % ($P < 0.01$), compared with the birds of the control group. The proportion of edible and inedible parts as well as the proportion of muscle and bones of broilers under the influence of this preparation also increased, respectively by 0.81 and 1.61 %. There were no statistically significant differences ($P > 0.05$).

Table 5. **The dissection data of the carcasses of the broiler chickens at the age of 35 days**

| Indices | Control group | Trial group | Probability |
|---|---|---|---|
| Body live weight, g | 2190.00±32.787 | 2236.67±182.779 | ** |
| Carcass weight, g | 1450.67±28.768 | 1468.00±131.103 | * |
| Weight of edible parts, g | 1277.67±18.844 | 1316.00±101.330 | * |
| Weight of inedible parts, g | 515.33±8.129 | 526.33±36.900 | NS |
| Muscle weight, g | 911.00±12.816 | 939.67±64.931 | ** |
| Bone weight, g | 293.33±3.253 | 298.00±14.309 | NS |
| Muscle and bone proportion | 3.10 | 3.15 | NS |
| Muscle $pH_{1h.}$<br>Muscle $pH_{24h}$ | 6.50<br>5.86 | 6.42<br>5.82 | NS |
| The data are statistically reliable: * ($P<0.05$), ** ($P<0.01$) | | | |

An important meat quality parameter is pH1h, which indicates a possibility of longer meat storage. Our research has demonstrated (Table 5), that the parameters of breast muscle pH1h and breast muscle pH24h were found to be similar (ranging from 5.82 to 5.86) among groups. There were no statistically significant differences ($P > 0.05$). Similar data were found by other authors (Maiorano *et al*., 2012).

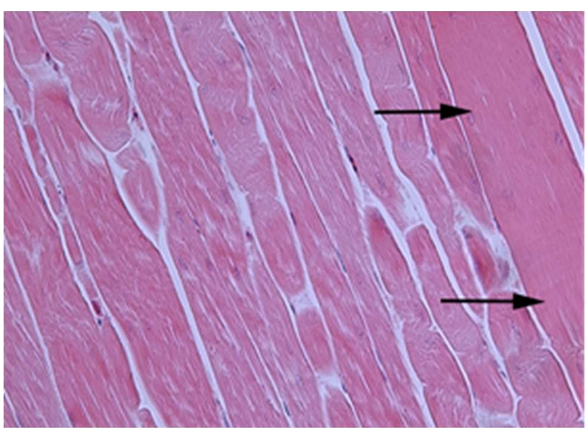

Fig.1. **Breast muscle fibers (longitudinal section). Stained with haematoxylin and eosin. Original magnification x100**.

Meat quality is determined by a variety of factors, including fibre thickness and muscle fascicles (Teusan *et al*., 2009). The obtained results were the muscular fibres of these muscles are grouped in the second and the third order muscular fascicles (Fig.1).

As muscles grow and develop, their mass increases. Muscle hypertrophy is manifested by the proliferation of muscle fiber proteins. Moreover, the muscle becomes longer due to the increase of sarcolemma.

Aging of the organism leads to structural and functional muscular changes, and muscle fibers decrease, muscle hypertrophy occurs, and the mass of the connective tissue increases. (Fig. 2).

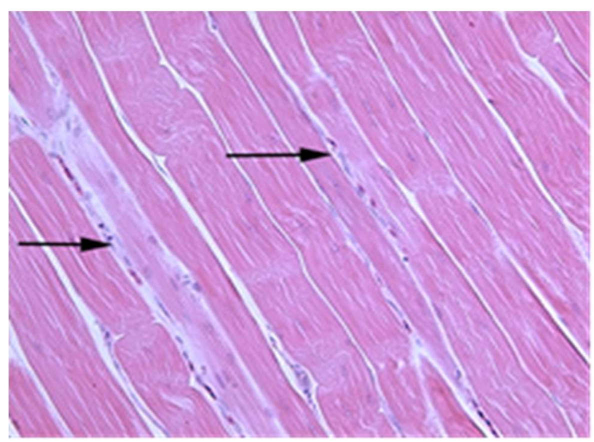

Fig. 2. **Breast muscle fibers (longitudinal section). Stained with haematoxylin and eosin. Original magnification x100.**

The major components of muscle are muscle fibers. Muscle fibres are specialized cells acting as the structural units of skeletal muscle tissue (Hedrick *et al*., 1994). It is well known that muscle fibre number, size, and fibre-type composition are closely related to each other (Ryu *et al*., 2004). In general, the fibre diameter varies from 10 to 100 μm but is dependent on such factors as health, species, breed, gender, age and the plan of nutrition (Choi and Kim, 2008). Fast-growing chickens have larger diameter fibre than slow-growing lines (Dransfield and Sosnicki, 1999). Nutrition in broiler chickens growth is a complex subject of major importance. Adequate nutrition is undoubtedly essential for normal skeletal muscle growth (Rehfeldt *et al*., 2004). Feed restriction in quantity and quality leads to decreased muscle fibre diameter (Fig.3)

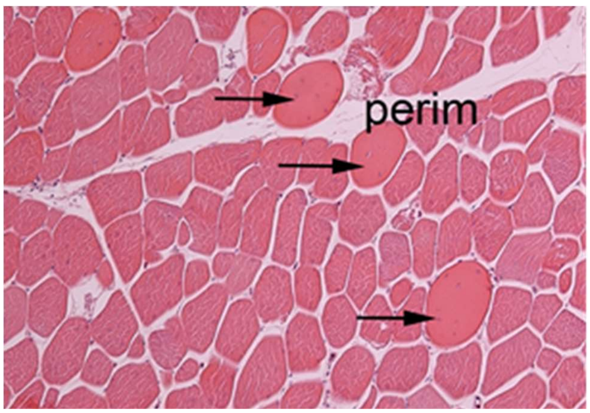


Fig. 3. **Breast muscle fibers (cross section). Stained with haematoxylin and eosin. Original magnification x100.**

Trial group chickens' breast muscle fibers with clear boundaries in perimysium and endomysium as well as occurring abnormal fibers are illustrated in Fig. 3.

In Fig.4. (control group) almost all the fibers appear abnormal.

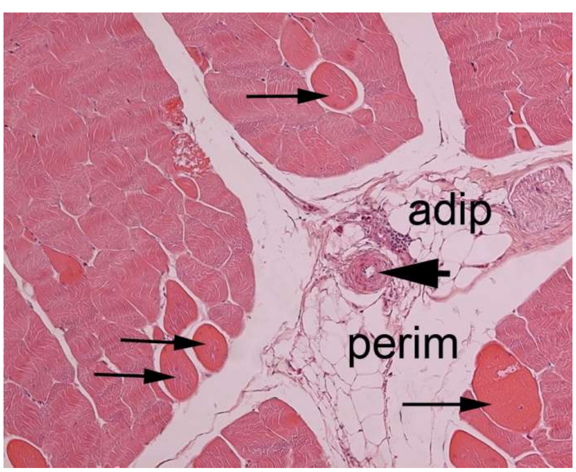


Fig. 4. **Breast muscle fibers (cross section). Stained with haematoxylin and eosin. Original magnification x100.**

**Conclusions.** Feed and water consumption is the major factor that influences both the body weight gain and feed conversion in meat-type poultry. Water treated with electromagnetic vibrations had a positive impact on the chemical composition of meat and carcass of meat. In the trial group, the amount of dry matter (P<0.05) and protein (P<0.05) in broiler chickens' meat was larger. The water treated with electromagnetic vibrations had a positive effect on broiler chicken carcass yield (P<0.05), the weight of edible parts (P<0.05) and muscle weight (P<0.01).

To sum up the results of the researches performed, it is possible to state that using water treated with electromagnetic vibrations as drinking water for chickens, the growth and performance may be improved.

Water treated with electromagnetic vibrations did not have any influence on histology of broiler chicken's skeletal muscles.

**References**

Alleman F. and Leclercq B. Effect of dietary protein and environmental temperature on growth performance and water consumption of male broiler chickens. Br. Poult. Sci. 1997. 38. P. 607–610.

AOAC. Official methods of analysis (15th Ed.) Association of Official Analytical Chemists. Arlington VA. 1990.

Barton T.L. Relevance of water quality to broiler and turkey performance. Poult. Sci. 1996. 75 (7). P. 854-856.

Blake J.P. and Hess J.B. Evaluating water quality for poultry. Alabama A & M University and Auburn University, Alabama Cooperative Extension System, Publication ANR-1201, Auburn and Huntsville, AL, USA. 2001.

Carter T.A. and Sneed R.E. Drinking water quality for poultry. Ext. Poult. Sci., Noth Carolina State University. 1998.

Cavani C., Petracci M., Trocino A., Xiccato G. Advences in research on poultry and rabbit meat quality. Ital. J. Anim. Sci. 2009. 8. P. 741-750.

Choi Y.M. and Kim B.C. Muscle fibre characteristics, myofibrillar protein isoforms, and meat quality. Livest Sci. 2008. P. 1-14.

Dransfield E. and Sosnicki A.A. Relationship between muscle growth and poultry meat quality. Poult. Sci. 1999. 78. P. 743-746.

Fairchild B.D. and Ritz C.W. Poultry drinking water primer. University of Georgia, Cooperative Ext. Bull. 2006. P. 1301.

Feddes J.J.R., Emmanuel E.J. and Zuidhoff M.J. Broiler performance, body weight variance, feed and water intake and carcass quality at different stocking densities. Poult. Sci. 2002. 81. P.774–779.

Ferket P.R. and Gernat A.G. Factors that affect feed intake of meat birds: A Review. 2006. Int. J. Poult. Sci. 5 (10). P. 905-911.

Fisinin V.I. and Surai P.F. First days of chicken life: From stress prevention to effective adaptation. Ptitzevodstvo (Moscow). 2012. 2. P. 11-15.

Fletcher D.L. Poultry meat quality. World's Poult. Sci. J. 2002. 58. P. 131–145.

Gomes H.A., Vieira S.L., Reis R.N., Freitas D.M, Barros R., Furtado F.V.F, and Silva P.X. Body weight, carcass yield, and intestinal contents of broilers having sodium and potassium salts in the drinking water twenty-four hours before processing. J. Appl. Poult. Res. 2008. 17. P. 369–375.

Hedrick H.B., Aberle E., Forrest J.C., Judge M.D., Merkel R.A. In Principles of Meat Science, Ch 3, Dubuque, Iowa, Kendall/Hunt publ. 1994. P. 55-78.

Lilburn M. S. Practical aspects of Early nutrition for Poultry. J. Appl. Poult. Res. 1998. 7. P.420-424.

Lott B.D., Dozier W.A., Simons J.D. and Roush W.B. Water flow rates in commercial broiler houses. Poult. Sci. 2003. 82 (Suppl.1). P. 102. P. 56.

LST EN ISO 10523:2012. Vandens kokybė. pH nustatymas (ISO 10523:2008).

LST EN ISO 14911:2000. Vandens kokybė. Ištirpusių Li+, Na+, NH4+, K+, Mn2+, Ca2+, Mg2+, Sr2+ ir Ba2+ nustatymas jonų mainų chromatografija. Vandens ir nuotėkų tyrimo metodas (ISO 14911:1998).

LST EN ISO 6222:2001. Vandens kokybė. Kultivuojamųjų mikroorganizmų skaičiavimas. Kolonijų standžioje mitybos terpėje skaičiavimas."

LST EN ISO 7899-2:2001. Vandens kokybė. Žarninių enterokokų aptikimas ir skaičiavimas. 2 dalis. Membraninio filtravimo metodas (ISO 7899-2:2000)

LST EN ISO 9308-2:2014. Vandens kokybė. Žarninių lazdelių (Escherichia coli) ir koliforminių bakterijų skaičiavimas. 2 dalis. Tikimiausiojo skaičiaus metodas (ISO 9308-2:2012).

LST ISO 6332:1995. Vandens kokybė. Geležies nustatymas. Spektrometrinis metodas naudojant 1,10-fenantroliną.

Maiorano G., Sobolewska A., Cianciullo D., Walasik K., Elminowska-Wenda G., Slawinska A., Tavaliello S., Żylinska J., Bardowski J. and Bednarczyk M. Influence of in ovo prebiotic and symbiotic administration on meat quality of broiler chickens. Poult. Sci. 2012. 91. P. 2963-2969.

Manning L., Chadd S.A. and Baines R.N. Key health and welfare indicators for broilers production. World's Poult. Sci. J. 2007. 63. P.47–62.

Marche G. Dissection of poultry carcasses – chicken, duck, turkey. INRA, (CD). 2000.

Marks H.I. The influence of dietary protein level on body weight of Japanese quail lines selected murder light and low protein diets. Poult. Sci. 1993. 72. P. 1012-1017.

Mazzoni M., Petracci M., Meluzzi A., Cavani C., Clavenzani P and Sirri F. Relationship between pectoralis major muscle histology and quality traits of chicken meat. Poult. Sci. 2015. 94. P. 123-130.

Ncube S., Hamudikuwanda H. and Saidi P.T. Voluntary feed intake and growth of broilers on *Acacia angustissima* leaf meal based starter and finisher diets. Livest. Res. Rur. Develop. 2012. 24 (8) P.1-6.

Patterson P.H., Lorenz E.S., Weaver W.D., Schwartz J.H. Litter production and nutrients from commercial broiler chickens. J. Appl. Poult. Res. 1998. 7. P. 247-252.

Petracci M. and Cavani C. Muscle growth and poultry meat quality issues. Nutr. 2012. 4. P. 1-12.

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

Rehfeldt C., Fiedler I., Sticland N.C. Number and size of muscle fibers in relation to meat production. *In: Te Pas M.F.W., Everts M.E., Haagsman H.P. (eds.): Muscle development of livestock animals: Physiology, Genetics and meat quality*. Cambridge, MA, Cabi Publisher, 2004. P. 1-38.

Ryu Y.C., Rhee M.S., Kim B.C. Estimation of correlation coefficients between histological parametres and carcass traits of pig longissimus dorsi muscle. J. Anim. Sci. 2004. 1. P. 428-433.

Ross 308 Broiler Performance Objectives, 2012

Teusan V., Radu-Rusu R.M., Teusan A. Investigations on the histological structure of the superficial pectoral muscle in Cobb-500 comercial meat-type hybrid hen. Cercetari Agronomice in Moldova. 2009. XLII. 4 (140). P.75-83.

Tumova E. and Teimouri A. Chicken muscle fibres characteristics and meat quality: a review. Sci. Agri. Boh. 2009. 40 (4). P. 253-258.

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 Poult. Sci. J. 2008. Suppl. 2. P.647.

Virden W.S., Dozier W.A. III, Corzo A. and Kidd M.T. Physiological stress responses in broilers as affected by drinking water supplements or dietary corn particle size 1,2. Appl. Poult. Resp. 2009. 18 (2). P. 244-251.

Watkins S.E. Water quality and sanitation. Poultry Digest Online. 2006. 3 (12). The paper was presented at the 2/library/SownLoad/PD 12 waterq.pdf.

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