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# The health status of turkeys against the microclimatic conditions

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**The objective of this study was to evaluate the sanitary microbiological status of a poultry house building as well as to determine morphological and biochemical blood markers of turkey hens with a deteriorated health status (diarrheas, numerous deaths, drowsiness, deformed tarsal joint). Microorganisms isolated from litter, buildings and turkey hens constituted the natural environmental flora detected in these types of buildings, hence the sanitary and hygienic status of the turkey rearing house was found satisfactory. The turkeys' hens with the poorer health status were characterized by worst production performance, decreased levels of hemoglobin, protein, alkaline phosphatase and minerals (Ca, Mg and Fe). In addition, increased levels were noted for lipid peroxidation products ($H_2O_2$, MDA), catalase, glucose, cholesterol, high-density lipoprotein (HDL) cholesterol fraction, uric acid, and lactic dehydrogenase.**

**Key words:** Turkey, health status, microclimate, blood parameters.

## INTRODUCTION

Optimal parameters of a poultry house environment are one of the key elements that determine the welfare of reared birds. Environmental factors, that is, hygiene, microclimate, feeding as well as various types of contaminations substantially affect the health status and production performance of animals (Kocaman et al., 2006). Amongst a variety of contaminations, great significance is ascribed to those of microbiological origin. In the case of a poultry house, they may originate from, among other things, feedstuff material, litter, walls of the hen house, floor cracks, drinkers, etc., and their number is determined by microbiological parameters. Apart from saprophytes, the microflora of poultry houses may as well include pathogenic microorganisms (Cencek et al., 2000). Hence, it is of great importance to provide the animals appropriate feeding and rearing conditions, which will enable eradication of diseases and thereby eliminate death of the animals. Bearing in mind the above, the objective of this study was to evaluate the sanitary microbiological status of a poultry rearing house as well as to determine the production, morphological and biochemical blood markers of turkey hens with deteriorated health status.

## MATERIALS AND METHODS

The experiment was carried out on Big 5 line turkey hens reared from the 1st to the 16th week of life. The turkey hens of all groups were fed *ad libitum* based on all-mash feed mixtures with a constant access to drinking water. The feed mixtures were

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**Table 1.** Nutrient content of the standard diets.

| Component (Feeding period) | Starter (1-2 week of age) | Grower I (3-5 week of age) | Grower II (6-9 week of age) | Grower III (10-12 week of age) | Finisher I (14-16 week of age) |
|---|---|---|---|---|---|
| Maize meal (%) | 25.6 | 27.4 | 23.8 | 35.2 | 47.4 |
| Wheat bran (%) | 20.0 | 25.0 | 30.0 | 25.0 | 25.0 |
| Wheat bran (%) | 3.0 | - | - | - | - |
| Soybean meal, 46% protein (%) | 41.0 | 41.7 | 38.8 | 32.7 | 20.4 |
| Soybean meal 45% protein (%) | 2.0 | - | - | - | - |
| Fish meal 60% (%) | 3.5 | - | - | - | - |
| Fodder chalk (%) | 1.2 | 1.7 | 1.7 | 1.4 | 1.5 |
| Soybean oil (%) | 0.5 | 1.0 | 2.5 | 3.0 | 3.0 |
| Cytromix Plus[1] (%) | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Farmix [1] (%) | 3.0 | 3.0 | 3.0 | 2.5 | 2.5 |
| **Nutrient composition** | | | | | |
| CP (%) | 27.1 | 25.5 | 24.5 | 22.0 | 17.5 |
| ME kcal $kg^{-1}$ | 2736 | 2803 | 2913 | 3007 | 3129 |
| Crude fibre (%) | 2.86 | 2.77 | 2.72 | 2.71 | 2.7 |
| Lysine % | 1.81 | 1.71 | 1.57 | 1.38 | 1.17 |
| Methionine +Cysteine (%) | 0.98 | 0.90 | 0.88 | 0.79 | 0.70 |
| Tryptophan (%) | 0.34 | 0.28 | 0.27 | 0.23 | 0.19 |
| Arginine (%) | 1.77 | 1.57 | 1.50 | 1.32 | 0.98 |
| Calcium (%) | 1.39 | 1.23 | 1.17 | 1.06 | 0.94 |
| Phosphorus available (%) | 0.77 | 0.67 | 0.59 | 0.57 | 0.47 |
| Sodium (%) | 0.15 | 0.16 | 0.15 | 0.15 | 0.15 |

[1]Cytromix Plus - citric acid. fumaric acid, phosphoric acid (62%); [2]Farmix– mineral and vitamin premix provided the following per kilogram of diet – 433333,0 IU of vitamin A; 133333,0 IU of vitamin $D_3$; 73,3 mg of vitamin $K_3$; 100,0 mg of vitamin $B_1$; 291,7 mg of riboflavin; 175,0 mg of vitamin $B_6$; 0,9 mg of vitamin $B_{12}$; 58,3 mg of folic acid; 10,5 mg of biotin; 2182,0 mg of niacin; 13333,0 mg of choline; 4 200 mg of calcium pantothenicum; 4 000 mg of Mn; 2 666 mg of Zn; 1 666 mg of Fe; 833 mg of Cu; 26 mg of I; 10 mg of Se; 6,7 mg of Co; 13 g of Ca; 15,5 g of P.

produced at the poultry farm based on recipes and premixes of the Polsanders-Poland company. All mixtures were composed based on wheat, maize meal, post-extraction soybean bean, soybean oil, with the iso-protein and iso-energetic balance maintained (Table 1). In addition, use was made of a Farmix type premix. Group I (n=12,000) included control birds with the normal health status, not displaying any pathological symptoms (proper body weight gains and feed intake). Birds belonging to group II (n=12,000) were turkey hens in which poorer health status was diagnosed on the 9th week of life (including: diarrheas, numerous deaths, drowsiness, deformed tarsal joint causing impaired walking), which resulted in the observed smaller body weight gains and feed intake. Birds of the experimental groups (I and II) were located in two separate turkey rearing houses: Building 1 (control birds) and building 2 (birds with a poorer health status). Owing to the fact that up to the 5th week of life the poults were located in the turkey rearing house, and since the 6th week of life they were fattened in different rearing buildings, the weekly weighing of turkey hens (100 turkey hens per building) was began since the 6th week of their life, and repeated after each completed week of life. Feed intake was monitored as well. Production performance results noted for particular groups were then used to calculate the European Production Performance Index WEO (Faruga and Pudyszak, 1999).

$$WEO = \frac{\text{mean body weight after rearing (kg) x liveability (\%) x 100}}{\text{day of rearing x feed conversion (kg kg -1)}}$$

On the 12th week of birds life, blood was sampled (by a veterinarian) from the wing vein of 100 birds from each group for morphological and biochemical analyses. The collected blood samples were determined for: hematocrit (Ht) number– with the microhematocrit method, hemoglobin (Hb) level – with the colorimetric method accounted to Drabkin, as well as for numbers of white blood cells (WBC) and erythrocytes (RBC) – with the chamber method (Bomski, 1989). The percentage composition of leucocytes (leucogram) was also determined by staining blood smears with the Pappenheim's method (Bomski 1989). Using monotests by Cormay company, blood plasma was assayed spectrophotometrically for levels of the selected biochemical markers, that is, total protein (TP), glucose (Glu), uric acid (UA), total cholesterol (CHOL), triacylglycerols (TG), high-density lipoprotein (HDL) and low-density lipoprotein (LDL) fractions of cholesterol. Samples of blood plasma were additionally analyzed for levels of: Zinc, iron, magnesium, calcium, and phosphorus – with the method of atomic absorption spectrometry (AAS). Further on, monotests by Cormey company were also used to determine the activity of alkaline phosphatase (ALP). Spectrophotometric analyses were also carried out in blood plasma to determine parameters of blood redox status: Superoxide dismutase (SOD) – with the adrenaline method accounted to Misra, in: Greenwald (1985), modified in respect of the wavelength of 320 nm. The method was modified to achieve higher selectivity of transitory reaction products at this wavelength (Bartosz, 1995). Catalase (CAT) was determined according to Bartosz (1995). In terms of the parameters of the antioxidative system, analyses were also carried out for the total antioxidant potential of plasma (FRAP) accounted

**Table 2.** Microorganisms identified in the rearing environment of turkeys and intensity of their occurrence.

| Sample collection site | Microorganisms /occurrence intensity | | | |
|---|---|---|---|---|
| Feeder | CNS (+) | *Trichosporon asahii* (+) | - | - |
| Drinker | *Candida crusei/inconspicua* (+) | *Trichosporon asahii* (++) | CNS (+) | *E. coli* (+) |
| Partitions/walls | CNS (++) | *Streptococcus fecalis*(+) | *Candida rusei/inconspicua* (+) | - |
| Litter | *Candida crusei/inconspicua* (+++) | CNS (+) | *Streptococcus fecalis* (+) | *E. coli* (++) |
| Cloaca | *Candida famata* (++) | *Candida crusei /inconspicua* (++) | *Streptococcus fecalis* (+) | *E. coli* (++) |
| Cloacal area | *Candida crusei /inconspicua* (+++) | *Trichosporon asahii* (+) | *Streptococcus fecalis* (+) | *E. coli* (+) |

+ Few, + + increase in the number, + + + abundant growth.

to Benzie and Strain (1996). Blood plasma of the experimental birds was also analyzed for the level of lipid peroxidation products, that is, concentration of peroxides ($H_2O_2$) according to Gay and Gębicki (2000, 2002), and concentration of malondialdehyde (MDA) as the end product of tissue lipids oxidation according to Ledwożyw et al. (1986).

In view of the fact that the problem of birds rearing referred exclusively to the turkey hens kept in one of the rearing buildings (building 2), it was stated that the problem was due to the poorer conditions of a turkey house microenvironment. For this reason, on the 12th week of birds rearing samples were collected from particular poultry houses for microbiological analyses. The material to be analyzed was litter collected into sterile containers as well as swabs collected with sterile cotton swabs from the birds (n=80) and from the walls and partitions inside the building. The collected material was transported in portable refrigerators to the laboratory and subjected to microbiological analyses. The samples were analyzed for microbiological contamination and for the occurrence of pathogenic bacteria of the genus *Salmonella*. The litter was fixed in a solution of physiological salt with the addition of *Tween 80*; next dilutions were prepared and inoculated onto McConkey's and Sabouraud's culture media. Swabs collected in the turkey rearing houses were inoculated from the cotton swabs onto the following media: Agar with blood and SS agar with pre-proliferation. The inoculates were incubated for 24 h at 37°C. Pure cultures were isolated from grown colonies by means of multiple reducing inoculations. Colonies were identified microscopically after staining accounted to Gram, by means of the following tests: Catalase, coagulase and biochemical tests API 20 C AUX by bioMerieux (bioMerieux Polska Ltd.).

Numerical data obtained were subjected to a statistical analysis using STATISTICA ver.5 software, with the one-way analysis of variance ANOVA, at a significance level of 0.05 and 0.01.

## RESULTS

The microbiological analyses of litter samples collected from both poultry rearing houses and of swabs collected from the birds demonstrated intensified occurrence of yeast-like fungi of the following genera: *Candida crusei, Candida famata* and *Trichosporon asahi.* The presence of *C. crusei* was detected in litter, on drinkers and in the cloacal area of the birds from both groups examined. *C. famata* was isolated mainly from the material collected with cotton swabs from the cloaca of turkey hens, whereas *T. asahi* – from drinkers and cloaca of the birds. The analyses did not demonstrate the presence of *Salmonella* genus bacilli in any of the samples collected from both turkey rearing houses. The other microbial species isolated from litter, buildings and animals represented the environmental microflora of this type of buildings that is *E. coli*, fecal streptococci – *S. faecalis,* and coagulase-negative staphylococci – CNS, usually having no impact on the pathological symptoms observed in the turkey hens from group II (Table 2). The main parameters of the rearing performance of turkey hens are presented in Table 3. As shown by data collated therein, in Group II the survivability of turkey hens was lower by 10.5% than in the control group. The observed (especially in the 10th week of life) disease symptoms in the turkey hens from Group II affected lower (than in the control group) body weight gains, that is, by 23.6% in 9 to 12 weeks of life, and by 15.4% in 13 to 16 weeks of life. In turn, in the period of 6 to 16 weeks of life, the body weight gains of the turkey hens from Group II were lower by 12% than those of the control birds. Data achieved were also reflected in values of the European Production Performance Index – WEO. A lower by 75.7 point value of that index was noted in Group II (372.5 point) when compared to the control group (448.2 point).

The main parameters of the hematological of blood of turkey hens are presented in Table 4. As shown by results achieved in the reported study, no differences were noted between the groups in the value of hematocrit and in the number of erythrocytes. In turn, the level of hemoglobin in the turkey hens with lower body weight gains and poorer health status turned out to be lower ($p \leq 0.05$) when compared to the control birds. The analysis of results achieved in the reported experiment demonstrated also a significant increase ($p \leq 0.05$) in the

**Table 3.** Production performance of turkey hens.

| Specification | Week of life | Experimental groups | |
|---|---|---|---|
| | | I – control | II |
| Weekly body weight gains (kg/bird) | 6-9 | 2.11 | 2.08 |
| | 9-12 | 2.79 | 2.13 |
| | 13-16 | 2.59 | 2.19 |
| | 6-16 | $7.58^{a}$ | $6.68^{b}$ |
| Feed intake (kg/kg) | 6-16 | 2.51 | 2.43 |
| Survivability (%) | | 95 | 85 |
| WEO, pts | | $448.2^{a}$ | $372.5^{b}$ |

$^{a,b}$ Values in rows denoted with different letter differ significantly at p≤0.05.

**Table 4.** Level of hematological blood markers of turkey hens.

| Marker | Feeding groups | | | | SEM |
|---|---|---|---|---|---|
| | I | | II | | |
| | M | SD | M | SD | |
| Ht ($L^{-1}$) | 0.29 | 0.023 | 0.28 | 0.012 | 0.006 |
| Hb (g $L^{-1}$) | $7.82^{a}$ | 0.35 | $6.58^{b}$ | 0.30 | 0.090 |
| RBC ($10^{12}$ $L^{-1}$) | 3.41 | 0.79 | 3.40 | 0.30 | 0.012 |
| WBC ($10^{9}$ $L^{-1}$) | $12.10^{b}$ | 1.47 | $19.5^{a}$ | 5.94 | 1.23 |

M, The arithmetic average; SD - standard deviation; $^{a, b}$ values in rows denoted with different letter differ significantly at p≤0.05. $^{A, B,}$ values in rows denoted with different letter differ significantly at p≤0.01.

**Table 5.** Level of biochemical blood markers of turkey hens.

| Marker | Feeding groups | | | | SEM |
|---|---|---|---|---|---|
| | I | | II | | |
| | M | SD | M | SD | |
| TP (g $L^{-1}$) | $78.9^{A}$ | 9.41 | $45.8^{B}$ | 4.34 | 1.12 |
| GLU (mmol $l^{-1}$) | $14.71^{b}$ | 0.93 | $17.08^{a}$ | 1.25 | 0.26 |
| CHOL (mmol $l^{-1}$) | $1.78^{b}$ | 0.52 | $2.77^{a}$ | 0.84 | 0.023 |
| HDL (mmol $l^{-1}$) | $1.83^{b}$ | 0.38 | $2.25^{a}$ | 0.38 | 0.082 |
| TG (mmol $l^{-1}$) | 0.29 | 0.05 | 0.32 | 0.05 | 0.024 |
| UA (µmol $l^{-1}$) | $234.1^{b}$ | 30.1 | $297.5^{a}$ | 37.6 | 3.45 |
| ALP (U $l^{-1}$) | $891.1^{A}$ | 79.5 | $476.94^{B}$ | 68.7 | 5.79 |
| LDH (U $l^{-1}$) | $858.7^{b}$ | 37.4 | $1082.3^{a}$ | 49.2 | 1.83 |

M, The arithmetic average; SD, standard deviation; $^{a, b}$, values in rows denoted with different letter differ significantly at p≤0.05 A, B, values in rows denoted with different letter differ significantly at p≤0.01.

level of white blood cells in the group of turkey hens with pathological signs (group II) compared to the control birds. The parameters of the biochemical of blood of turkey hens are presented in Table 5. The reported study did not demonstrate any significant differences between the groups in terms of the levels of triglycerides. Furthermore, a significant (p≤0.01) decrease was observed in the levels of total protein and alkaline phosphatase in the group of turkey hens displaying poorer health status, compared to the control birds. In the case of turkey hens exhibiting the poorer health status also levels of glucose, uric acid, cholesterol with HDL fraction, and the activity of lactic dehydrogenase appeared to be significantly (p≤0.05) higher than in the control birds. The results obtained in our study point also to a significant, compared to the control group, increase

**Table 6.** Level of mineral components in blood of turkey hens.

| Mineral component | Feeding groups | | | | SEM |
|---|---|---|---|---|---|
| | I | | II | | |
| | M | SD | M | SD | |
| Ca (mmol $L^{-1}$) | 3.52[a] | 0.30 | 2.91[b] | 0.51 | 0.013 |
| Mg (mmol $L^{-1}$) | 0.95[a] | 0.08 | 0.80[b] | 0.08 | 0.010 |
| P (mmol $L^{-1}$) | 1.79 | 0.14 | 1.95 | 0.21 | 0.071 |
| Zn (µmol $L^{-1}$) | 10.88[b] | 3.50 | 18.65[a] | 8.78 | 1.14 |
| Fe (µmol $L^{-1}$) | 72.5[a] | 3.59 | 59.6[b] | 5.32 | 1.04 |
| Mn (µmol $L^{-1}$) | 0.542 | 0.15 | 0.536 | 0.14 | 0.021 |

M, The arithmetic average; SD - standard deviation; [a, b], values in rows denoted with different letter differ significantly at p≤0.05.

**Table 7.** Level of pro- and antioxidative markers in blood of turkey hens.

| Marker | Feeding groups | | | | SEM |
|---|---|---|---|---|---|
| | I | | II | | |
| | M | SD | M | SD | |
| $H_2O_2$ (µmol $L^{-1}$) | 2.34[b] | 0.83 | 3.85[a] | 0.07 | 0.19 |
| MDA (µmol $L^{-1}$) | 6.49[b] | 1.82 | 7.7[a] | 1.08 | 0.058 |
| SOD (U $ml^{-1}$) | 25.93 | 0.11 | 26.19 | 0.24 | 0.24 |
| CAT (U $ml^{-1}$) | 6.88[b] | 1.98 | 9.03[a] | 1.90 | 0.27 |
| FRAP (µmol $L^{-1}$) | 63.7 | 9.77 | 68.9 | 3.21 | 1.50 |

M, The arithmetic average; SD, standard deviation; [a, b,] values in rows denoted with different letters differ significantly at p≤0.05.

in the level of uric acid and urea in blood plasma. As shown by data presented in Table 6, there were no significant differences between the groups in the contents of phosphorus and manganese. The values reported for contents of calcium, magnesium and iron were significantly (p≤0.05) lower in Group II when compared to control birds. Values of the parameters of the redox system in blood plasma of turkey hens are presented in Table 7. No significant differences were noted between the groups in the activity neither of SOD nor in the level of FRAP. The analysis of results achieved in the reported experiment demonstrated also increase level of hydrogen peroxide and MDA in Group II by 39.2 and 15.7%, respectively compared to the control birds. Also the activity of CAT in the group of birds exhibiting pathological symptoms was higher (by 23.8%) than in the control group.

## DISCUSSION

Worthy of notice is the fact that the microflora of litter displays some dynamics of changes closely linked with microclimatic conditions occurring in farm buildings. Amongst the saprophytic microorganisms the pathogenic ones are also likely to occur. All isolated fungi species are often detected in the farm environment and represent opportunistic microorganisms that may become causative agents of a disease only under specified conditions. The microclimatic conditions in a building, feces composition and, consequently, litter parameters are changing over the entire rearing cycle of turkeys, which affects the sanitary status of litter. Such changes trigger the modification of bioaerosol in the air of the turkey rearing house, and with the air falling down changes are also proceeding in the microbiological composition of the surface of walls and partitions (Trawińska et al., 2008; Kołacz, 2000). As reported by Kołacz (2000), the hygienic status of the microenvironment animals are living in exerts a significant effect on their health status and rearing performance.

Hematological analyses are among the methods which may contribute to the detection of some changes in health status and can be a useful aid for diagnosis diseases in birds (Moreira dos Santos Schmidt et al., 2009). Levels of the hematological and biochemical blood markers of birds are affected by a number of factors, including age, sex, species, breed, feeding, physiological status, and rearing technology. Birds are additionally characterized by considerable individual diversification (Koncicki and Krasnodębska-Depta, 2005). As shown by results achieved in the reported study, no differences

were noted between the groups in the value of hematocrit and in the number of erythrocytes. It should be emphasized, however, that the Ht values of turkey hens from both groups turned out to be lower than the reference values for turkeys (0.30 – 0.33) (Koncicki and Krasnodębska–Depta, 2005) and then the values reported elsewhere (Krasnodębska-Depta et al., 2003). In turn, the level of hemoglobin in the turkey hens with lower body weight gains and poorer health status turned out to be lower when compared to the control birds Despite the observed differences in hemoglobin level, the values reported were corresponding with results achieved for turkeys hens (without pathological symptoms) by Czech et al. (2010) and by Krauze et al. (2007). Results of the increased levels of hemoglobin and hematocrit in turkeys in the course of histomonadosis were noted by Koncicki et al. (1999).

In contrast, diminished levels of the erythrocytic system markers in turkeys infected with a pathogenic strain of *E. coli* bacilli were noted by Krasnodębska–Depta et al. (2003). The decreased level of hemoglobin is a symptom of anemia. It also occurs, though to a lesser extent, after hemorrhages as well as in the course of infectious, parasitic diseases and intoxications (Stankiewicz, 1973b). According to Konwicki and Krasnodębska–Depta (2005), it may also be due to pathogenic conditions, that is, colibacteriosis and coccidiosis. The increased levels of the erythrocytic system markers may also be explained by the condensation of blood due to body dehydration resulting from diarrhea. Hence, there is no simple elucidation of the reduced level of hemoglobin noted in our study owing to the observed symptoms of diarrhea occurring in the birds. The analysis of results achieved in the reported experiment demonstrated also a significant increase in the level of WBC in the group of turkey hens with pathological signs. The increased level of WBC in the course of histomonadosis in turkey hens was noted by Konicicki et al. (1999). Likewise, an increase in leucocytes level in the pathogenic condition of birds was observed by Krasnodębska–Depta et al. (2003).

The increased level of WBC in turkeys was also reported as affected by the administration of biostimulants (Czech et al., 2010; Truchliński et al., 2005a). In contrast, the diminished level of leucocytes resulting from the administration of synthetic antioxidants to turkey hens. Leucocytosis, that is, an increased number of leucocytes, occurs in the case of coccidiosis, in the acute course of salmonellosis and colibacteriosis in chickens and turkeys, as well as in histomonadosis and intoxication of turkeys with ionophore coccidiostats (Koncicki et al., 2000). As reported by Winnicka (2008), leucocytosis may appear in neoplasmic diseases, leukemias, anemias and different inflammatory states in the body. While elucidating the effect of biostimulants on WBC level increase, other researchers emphasize that leucocytosis may also indicate the stimulation of the immune system (Sembratowicz et al., 2004; Wagner, 1996). The reported study did not demonstrate any significant differences between the groups in terms of the levels of TG. Nevertheless, worthy of notice is the noted TG level which in both groups turned out to be significantly higher than the reference values stipulated for turkeys (1.06 - 1.57) (Koncicki and Krasnodębska–Depta, 2005; Winnicka, 2008), and then the values reported by Makarski and Zadura (2006). The reduced concentration of triacylglycerols is observed in the case of afla- and ochratoxin as well as in monoensin intoxication (Rostek, 2010). In spite of that, the reported values of the above-mentioned markers were corresponding with results of a study conducted on turkeys by Rostek (2010). The increased level of total protein in the course of histomonadosis was noted by Koncicki et al. (1999). Also Krasnodębska–Depta et al. (2003) observed an increase in total protein level in plasma of turkeys infected with a pathogenic strain of *E. coli* bacilli. The same authors reported on a significant suppression of alkaline phosphatase activity in the study on turkeys infected with a pathogenic strain of *E. coli* bacilli. The suppressed activity of this enzyme may be indicative of turkeys anemia. It is also reported in the case of the inflammatory state of bones and in green liver disease (Bayyari et al., 1997; Krasnodębska–Depta et al., 2003).

According to Koncicki and Krasnodębska–Depta (2005), the reduced level of this marker was also noted as a result of heat stress in ducks, IBD (Gumboro disease), colibacteriosis of turkeys, and turkeys intoxication with salinomycin and furazolidone. In contrast, an increased level of this marker is observed in the course of rickets and osteomalacia, aflatoxins intoxication in hens and ducks, and neoplasmic processes in bones. Hypoproteinemia, namely a condition characterized by a decreased level of total protein, occurs in the case of protein losses to exudates (round heart disease of turkeys), in the course of viral diseases, that is, Gumboro disease, hydropericardium hepatitis syndrome and Newcastle disease, ochratoxicosis in hens, monoensin intoxication in turkeys, and under the influence of heat stress in hens and turkeys (Koncicki and Krasnodębska – Depta, 2005). According to Stankiewicz (1973a), it may also be due to enteric ailments, e.g. diarrhea, which corresponds with results of our study on turkeys with the observed cases of diarrhea. In turn, an increase in the total protein level (hyperproteinemia) is observed in conditions of rehydration, histomonadosis and colibacteriosis of turkeys (Koncicki and Krasnodębska–Depta, 2005).

The increased levels of glucose and uric acid were also observed by Truchliński et al. (2005a, b) in their experiments with turkey hens (without pathological symptoms). Stankiewicz (1973a) reports that hyperglycemia occurs also as a result of hypoxia and acute infectious diseases. The increased level of cholesterol in turkeys administered biostimulating

preparations was also observed by Dmoch and Polonis (2007) as well as by Makarski and Zadura (2006). Similar results of the increased cholesterol level in the course of histomonadosis were noted by Koncicki et al. (1999) and Krasnodębska–Depta et al. (2003) in turkeys infected with a pathogenic *E. coli* strain. According to Koncicki and Krasnodębska–Depta (2005), hypercholesterolemia – being the condition characterized by an increased level of cholesterol, occurs in the course of histomonadosis in turkeys and MD (Marek diseases), as well as IBD in hens. The increased concentration of glucose (hyperglycemia) was observed in the course of amyloidosis in geese and ducks, ochrotoxin intoxication in chickens and upon heat stress in ducks. The increased values of those markers are likely to be due to hepatitis and kidney failure, as well as due to accelerated catabolism of proteins which usually occurs in bacterial diseases (Krasnodębska–Depta et al., 2003). The increased level of uric acid is also reported as a result of infectious diseases – ND, IBD, HHS (hydropericardium hepatitis syndrome) and colibacteriosis of turkeys, in the course of gouty diathesis and ochratoxin intoxication in hens, and ionophore coccidiostatics intoxication in turkeys (Koncicki and Krasnodębska–Depta, 2005). As indicated by literature data, increased levels of LDH enzyme may be observed in the course of histomonadosis (Koncicki et al., 1999) and in turkeys infected with a pathogenic strain of *E. coli* bacilli (Krasnodębska–Depta et al., 2003).

The enhanced activity of LDH may result from damage of liver and cardiac muscle (Makarski and Zadura, 2006; Truchliński et al., 2005a). Similar observations were made by Koncicki and Krasnodębska–Depta (2005) and Koncicki et al. (1999) who have, additionally, claimed that this condition is maintaining in all diseases proceeding with tissue necrosis, in the course of histomonadosis in turkeys, in intoxications with aflatoxin and monoensin, and as a result of many infectious diseases, including IBD, HHS and colibacteriosis. In the case of the turkey hens characterized by lower body weight gains and poorer health status, the study demonstrated also reduced levels of calcium, magnesium and iron. A diminished level of calcium in the case of turkeys exposed to a short-term heat stress was reported by Krasnodębska–Depta and Koncicki (2002). In turn, a reduced level of iron in blood of turkey hens receiving an additive of synthetic antioxidants was noted by Czech et al. (2010), whereas decreased levels of calcium and iron in turkeys administered copper chelate – by Dmoch and Polonis (2007).

According to Konwicki and Krasnodębska–Depta (2005), both an increase and a decrease in calcium level are observed in the case of rickets and osteomalacia, and as a result of many infectious diseases and intoxications. The observed decrease in the level of iron may be elucidated by the increased utilization of this element for heme synthesis, which may in a consequence affect an increase in hemoglobin level (Brodacki et al., 2006). Hence, the diminished level of iron recorded in our study may be the reason of the reduced hemoglobin level in blood of the turkey hens from group II. In turn, the reported decrease in the level of magnesium may contribute to disorders in calcium and potassium metabolism as well as in water-electrolyte balance (Kłopocki and Winnicka, 1987). A significant ($p \leq 0.05$) increase in the blood level of zinc, when compared to the control birds, was observed in the group of turkey hens with a poorer health status (Group II). The increased level of this element was also reported as a result of biostimulants administration to turkeys (Ognik et al., 2004; Ognik and Sembratowicz, 2007). The excessive content of zinc may inhibit the absorption of copper and iron and accelerate the excretion of iron from the body. The high level of zinc additionally hinders iron and copper complexation into a heme molecule and may be the causative agent of anemia (Murray et al., 1994; Kleczkowski et al. 2004).

The maintenance of the balance between neutralization and production of reactive oxygen species is indicated by the enhancement in the activity of catalase as well as by increased levels of hydrogen peroxide and MDA in Group II. A lack of works addressing the effect of the pathological condition in poultry, turkeys in particular, on blood levels of redox parameters makes the comparison and confrontation as well as in-depth reference of own results with findings of other authors difficult. The higher level of MDA at the suppressed activity of SOD and CAT was noted by Truchliński et al. (2007) in turkey hens exposed to cooling and crowding stress. The observed increase in the concentration of lipid peroxidation products, that a significant increase in peroxides and malondialdehyde, indicates the oxidative stress occurring in the body of the birds (Truchliński et al. 2007). As shown in literature data (Kleczkowski et al., 2004; Ogryczak et al., 2001), the diminished activity of catalase is usually observed at the onset of the pathological process, whereas its enhancement appears after disease termination. The reported decrease in the level of iron might have also be the reason of the suppressed activity of catalase (Czech et al., 2010; Wieleba and Pasternak, 2001), for iron is the activator of this enzyme.

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