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Effect of pig housing system on blood biochemical indicators' level

Wpływ systemu utrzymania trzody chlewnej na poziom wskaźników
biochemicznych krwi

Summary. The aim of the study was to evaluate the influence of different pig housing systems on the level of chosen biochemical indicators in pig's blood. The level of ACTH along with haptoglobin, lysozyme and IgG were determined in 20 sows and 150 piglets of crossed breeds: Polish Large White × Polish Landrace. The animals were kept in two different housing conditions: two facilities contained straw bedding (sows n = 10, piglets n = 75) in other two slatted floor without straw bedding access (sows n = 10, piglets n = 75). Biochemical indicators in sows and piglets were determined by taking blood samples after weaning (at the piglets' age of ca. 30 days). Statistically significant influence of the housing system on the value of the determined indicators was showed. The level of both ACTH and immunity indicators was statistically significantly higher in animals housed without bedding. In sows the values of all indicators were higher than in piglets. The housing system on straw bedding turned out to be more favourable for pigs. Animals housed on slatted floor were more stressful.

Key words: animal welfare, housing system, immunity, pig, stress

INTRODUCTION

The profitability of pig production depends on many factors. They include among others the quality of raw material, relationships between the prices of ready products and products being sold [Tawse 2010]. Fattening results have major influence on costs and revenues, determined by genetic and environmental factors, including in particular feed-

ing and housing system [Barnett *et al.* 2001]. The immune system could be suppressed in response to unfavourable environmental conditions, which results in the decrease in growth rate, the occurrence of homeostasis system disturbances as well as decreased use of the feed [Gonyou *et al.* 2006]. Current preferences of consumers who tend to pay attention to the quality and safety of food motivate producers more and more often to ensure the appropriate level of animal welfare [Tawse 2010]. In evaluating stress induced animal discomfort caused inadequate welfare helpful tool would be investigation of certain blood biochemical parameters [File 1996]. Level of catecholamines and the ACTH (adrenocorticotrophic hormone) in blood are used to assess the degree of stress. ACTH, responsible for the secretion of glucocorticoids, is the main hormone produced by the anterior lobe of the pituitary gland. As it is the case with other stress hormones, its level changes in the conditions of decreased animal welfare [Zhang *et al.* 1990]. Level of acute phase proteins are important diagnostic criterion both in diagnostic of presence of different diseases [Spurlock, 1997] as well as assessing the health and welfare of an animal [Kostro *et al.* 2001]. The existence of strict relationship between the increased level of acute phase proteins and deteriorated environment or specific physiological state of an animal was pointed out by numerous authors [Kostro *et al.* 2001, Budzyńska 2002, Budzyńska *et al.* 2003]. In pigs, main acute phase proteins are haptoglobin (Hp), serum amyloid A (SAA), C-reactive protein (CRP), pig Major Acute Phase Protein (pig MAP) as well as albumins and fibrinogen [Piñeiro *et al.* 2009]. The level of immunoglobulins constitutes an important immunological factor for the assessment of animal health and welfare. The range of reference standards for G class immunoglobulins varies between 5.2 and 58.1 g/l [Winnicka 2004]. Research conducted by Lechowski *et al.* [1998] demonstrates that the stress caused by the change of cages and isolation of pigs results in the decrease of the IgG fraction and the increase of C-reactive protein, ceruloplasmine as well as lysozyme activity. Both, acute phase proteins and lysozyme play important role in non-specific humoral immunity. The decrease in the secretion of immunoglobulins is also caused by the stress affecting pregnant sows [Barnett *et al.* 2001]. According to Rooke and Bland [2002], the level of IgG in blood serum of piglets is correlated with the amount of already received colostrum, IgG concentration in colostrum as well as with the time which has elapsed since bowel wall became impermeable to immunoglobulins.

The aim of the study was to evaluate the influence of different pig housing systems (with and without straw bedding) on the level of chosen biochemical indicators in pig's blood.

MATERIAL AND METHODS

The research was conducted in four pig farms of the Lublin region. The analysed source of variability was the pig housing system. In two piggeries the animals were housed on straw bedding (sows $n = 10$, piglets $n = 75$) and in two other without bedding, on slatted floor (sows $n = 10$, piglets $n = 75$). It covered 20 sows and 150 piglets of crossed breeds: Polish Large White \times Polish Landrace staying with their mothers until weaning. Age, animal feeding and care were similar in each facility. All animals were healthy and supervised by the veterinarian. Animal care and experimental procedures were conducted in accordance with European Commission regulations on the protection of the experimental animals and were approved by the Local Ethics Committee for animal

experiments in accordance with resolution No. 48/2010. Biochemical indicators of stress and immunological status in sows and piglets were determined by taking blood samples after weaning (at the piglets' age of ca. 30). The blood sample for analysis was taken from the animal's external jugular vein about 8 am. Stress indicator – the level of adrenocorticotrophic hormone (ACTH) in blood serum was determined with the ELISA (Bio-merica) test. Immunity indicators – the level of IgG in blood serum was determined with the ELISA (Alpha Diagnostic International) test. The concentration of haptoglobin (Hp) in blood serum was determined basing on the peroxidase reaction of the Hp complex with haemoglobin, by means of the radial immunodiffusion method ("Phase™ Range" Tridelta Development Limited). The results were read basing on the calibration curve. The level of lysozyme (Ly) was determined by means of the plate method according to Hankiewicz i Świerczek [1974].

Statistical interpretation of research results was performed with the use of the Statistica version 10.0 (StatSoft, Poland). The influence of the housing system on biochemical indicators in the blood serum of sows was determined by Student's t-test in the variant with independent variance estimation. Differences were considered as significant when p values were less than 0.01 and 0.0001.

RESULTS AND DISCUSSION

Different content of ACTH in blood serum of animals kept in different housing systems was reported. In pigs housed on slatted floor without bedding the level of ACTH was 58.20% higher in comparison with those housed on straw bedding and exceeded referential values: 0.04–0.63 ng/ml [Winnicka 2004]. Average level of this hormone in sows housed on straw bedding amounted to 3.42 ng/ml, while in the housing system without bedding access it reached 5.41 ng/ml (tab. 1).

Table 1. Descriptive statistics of biochemical indicators in the blood serum of sows depending on the housing system

Tabela 1. Wskaźniki biochemiczne we krwi macior z uwzględnieniem systemu utrzymania

| Biochemical indicators Wskaźniki biochemiczne | Housing system System utrzymania | Mean Średnia | SD | Min | Max | p-value Wartość p |
|--|-------------------------------------|-----------------|--------|---------|---------|----------------------|
| ACTH (ng · ml ⁻¹) | 1 | 3.42 | 2.17 | 0.69 | 7.92 | 0.0035 |
| | 2 | 5.41 | 0.53 | 4.14 | 6.00 | |
| IgG (μg · ml ⁻¹) | 1 | 3824.84 | 554.20 | 2731.69 | 4368.45 | 0.0002 |
| | 2 | 4520.83 | 585.48 | 3690.06 | 5384.60 | |
| Hp (mg · ml ⁻¹) | 1 | 2.71 | 1.18 | 1.10 | 5.53 | 0.0019 |
| | 2 | 4.03 | 0.93 | 1.15 | 5.53 | |
| Ly (mg · l ⁻¹) | 1 | 1.37 | 0.73 | 0.68 | 3.80 | 0.1784 |
| | 2 | 1.65 | 0.30 | 1.27 | 2.30 | |

1 – with straw bedding, 2 – without straw bedding

1 – utrzymanie ściółkowe, 2 – utrzymanie bezściółkowe

Similar trends were observed in piglets. In the housing system without bedding the level of ACTH was nearly seven times higher than in the system with bedding (tab. 2) and exceeded the norms. In piglets kept on bedding the level of ACTH was in the range of preferred values. The content of ACTH in blood serum was significantly differentiated according to the housing system in both sows ($p < 0.01$, tab. 1) as well as piglets ($p < 0.0001$, tab. 2). Increased IgG level was observed in sows housed without bedding, on average 4520.83 $\mu\text{g/ml}$. In the straw bedded system it was lower and amounted on average to 3824.84 $\mu\text{g/ml}$ (tab. 1). Similar trend was observed in piglets (tab. 2). In the non-bedded system IgG content amounted to 2042.21 $\mu\text{g/ml}$. In piglets housed on straw bedding it was lower and amounted on average to 1143.45 $\mu\text{g/ml}$. Differences in the IgG content in animals housed in different systems were statistically significant (tab. 1, 2). In sows housed on straw bedding the concentration of Hp reached 2.71 mg/ml, while in those kept on slatted floor it amounted to 4.03 mg/ml (tab. 1). Housing system highly significantly differentiated the level of Hp in sows ($p < 0.01$, tab. 1) and piglets ($p < 0.0001$, tab. 2).

Table 2. Descriptive statistics of biochemical indicators in the blood of piglets depending on the housing system

Tabela 2. Wskaźniki biochemiczne we krwi prosiąt z uwzględnieniem systemu utrzymania

| Biochemical indicators Wskaźniki biochemiczne | Housing system System utrzymania | Mean Średnia | SD | Min. | Max | p-value Wartość p |
|--|-------------------------------------|-----------------|--------|---------|---------|----------------------|
| ACTH ($\text{ng} \cdot \text{ml}^{-1}$) | 1 | 0.47 | 0.25 | 0.03 | 1.47 | <0.0001 |
| | 2 | 3.24 | 0.70 | 1.44 | 5.78 | |
| IgG ($\mu\text{g} \cdot \text{ml}^{-1}$) | 1 | 1143.45 | 158.44 | 113.60 | 1932.44 | <0.0001 |
| | 2 | 2042.21 | 439.04 | 1008.12 | 3470.80 | |
| Hp ($\text{mg} \cdot \text{ml}^{-1}$) | 1 | 0.41 | 0.25 | 0.04 | 1.58 | <0.0001 |
| | 2 | 1.35 | 0.48 | 0.10 | 3.99 | |
| Ly ($\text{mg} \cdot \text{l}^{-1}$) | 1 | 0.56 | 0.23 | 0.08 | 1.00 | <0.0001 |
| | 2 | 1.26 | 0.48 | 0.00 | 3.00 | |

1 – with straw bedding, 2 – without straw bedding

1 – utrzymanie ściółkowe, 2 – utrzymanie bezściółkowe

The content of haptoglobin in blood serum of piglets housed on straw bedding was at the average level of 0.41 mg/ml (tab. 2). In piglets housed on slatted floor without bedding the Hp level was 1.35 mg/ml (tab. 2). Significant ($p < 0.0001$) influence of the housing system modifying the content of lysozyme in blood serum of only piglets has been stated. In piglets kept on straw bedding it was 0.56 mg/l, while as far as the system without bedding is concerned – 1.26 mg/l (tab. 2). The content of lysozyme in sows housed on straw bedding amounted on average to 1.37 mg/l. In sows kept according to the housing system without bedding it reached 1.65 mg/l (tab. 1). Changes in the living conditions and in technological processes on pig farms have an important influence on the homeostasis level [Barnett *et al.* 2001]. Animals respond to the influence of the environment in

different ways and by different reactions, adapting to it faster or slower or not adapting at all. Biochemical tests enable the assessment of internal equilibrium of the organism, which is influenced by various factors of the environment, including infectious and non-infectious ones. It is difficult to prove the correlation between stress and disease, as it is difficult to perform the objective evaluation of stress [Gonyou *et al.* 2006]. The results of numerous studies demonstrate the decrease in immunity after the occurrence of stress; however, short-term stress may stimulate certain parameters of the immune system. The decrease in immunity is observed during temporary deterioration of animal housing conditions [Barnett *et al.* 2001]. ACTH stress indicator determined in this work provides the information on the adaptation of the organism to stress. Due to the fact that the concentration of the adrenocorticotrophic hormone is not subject to as dynamic changes as the concentration of cortisol [Zhang *et al.* 1990], from all biochemical indicators of stress (animal welfare) only ACTH was determined. Authors' own research showed that the conditions of housing without bedding were more stressful especially for piglets: level of ACTH was seven times higher than it was in the case with piglets housed on straw bedding. It can be assumed that in this way the animals launched the mechanism of adaptation to being housed without bedding. As a response of the acute phase, the increase in the synthesis of certain hormones – insulin, glucagon, ACTH, cortisol, catecholamine, somatotropin, and vasopressin is observed [Kostro *et al.* 2001]. The literature available on the subject does not include any data on the potential influence of the housing system on the level of ACTH. However, some data showed the influence of animals living conditions on cortisol level. The research by Morrison *et al.* [2007] demonstrates that the concentration of cortisol in pigs was higher in deep bedding group housing system at the age of 9 weeks. Hick *et al.* [1998] and Fischer *et al.* [1997] present that the level of this hormone as well as the concentration of Hp was increasing also at unfavourable temperatures, during competition in the litter or after castration. The increase in the ACTH content observed in this research housed without bedding might have been caused by the lack of bedding, the material to play with or to dig in.

IgG level was also determined in the study. The range of referential values for IgG is broad, as it falls between 5200 and 58100 $\mu\text{g/ml}$ [Winnicka 2004]. Our research showed that the content of IgG in blood serum of sows (tab. 1) and piglets (tab. 2) fell below the norm. Important process connected with the adaptation to pathology and managing pigs it is the acute phase reaction [Gregory 1998, Jakubowski *et al.* 2004]. The research on different animal species [Kostro *et al.* 2001, Budzyńska *et al.* 2003, Jakubowski *et al.* 2004] showed the increase in the content of Hp in blood serum as a result of improper microclimatic conditions, age, specific physiological state (e.g. pregnancy, lactation) as well as experimental and natural immunization. Monitoring the changes in the level of Hp pig's blood serum is not only important from the diagnostic point of view, but it also provides information on the health and welfare of animals [Piñeiro *et al.* 2009]. Sobieska *et al.* [1995] claim that Hp monitoring may constitute the indicator of the quality of pork. According to Kostro *et al.* [2001] physiological concentration of Hp in pigs amounts on average to 0.33 mg/ml, ranging from 0.19 to 0.52 mg/ml. Amory *et al.* [2007] consider Hp as a sensitive indicator. Piñeiro *et al.* [2009] as well as Pallares *et al.* [2008] state that the increase in the level of Hp occurs with age that is in agreement with our findings (tab. 1, 2). In the conducted research the level of acute phase protein was determined at the example of Hp. It has been demonstrated that the housing system highly significantly

differentiated the level of Hp in sows ($p < 0.01$) and piglets ($p < 0.0001$). Lysozyme is a very important defence factor of the animal organism. High value of this indicator may constitute a proof of initiation of non-specific immunological response after the contact with an antigen or stressor. Lechowski *et al.* [1998] demonstrated that the stress connected with the change of cages and isolation of pigs resulted in the decrease in IgG level as well as increase in acute phase proteins and lysozyme activity. In the study of Lechowski *et al.* [1998] considering stress influence on biochemical indices in the pig serum the lysozyme level ranked from 0.82 ± 0.28 mg/l to 1.03 ± 0.24 mg/l. In this research the content of lysozyme reached in sows 1.37 mg/l in with bedding and 1.65 mg/l in without bedding while in piglets 0.56 mg/l in with bedding and 1.26 mg/l in without bedding. It was also demonstrated that the housing system differentiated the level of lysozyme only in piglets. Sotirov [2006] has reported that there are significant differences in serum concentration of lysozyme in various swine breeds but not in different age groups.

CONCLUSIONS

1. It is possible to state that housing system significantly influenced the level of stress and immune indicators marked in the pig's blood.
2. The level of both stress (ACTH) and immunity indicators (Hp, IgG, Ly) was statistically significantly higher in animals housed without straw bedding.
3. In sows the values of all indicators were higher than in piglets.
4. The housing system on straw bedding turned out to be more favourable for pigs. Animals housed on slatted floor were more stressful.

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Streszczenie. Celem pracy była ocena wpływu różnych systemów utrzymania na poziom wybranych wskaźników biochemicznych we krwi świń. U 20 macior i 150 prosiąt (wbp × pbz) oznaczono poziom ACTH, haptoglobiny, lizozymu i IgG. Zwierzęta były utrzymywane w różnych warunkach: w dwóch chlewniach (10 macior i 75 prosiąt) na ściółce, a w dwóch kolejnych (10 macior i 75 prosiąt) bezściołowo. Wskaźniki biochemiczne u macior i prosiąt były oznaczane we krwi pobranej bezpośrednio po odsadzeniu (prosięta były w wieku około 30 dni). Wykazano, że system utrzymania miał statystycznie istotny wpływ na analizowane wskaźniki. Zarówno poziom ACTH, jak i wskaźników odpornościowych był wyższy u świń utrzymywanych bez ściółki. U macior poziom analizowanych wskaźników był ponadto wyższy niż u prosiąt. System ściółkowy okazał się bardziej korzystny dla świń. Zwierzęta utrzymywane na podłożu bezściołowym charakteryzowały się wyższym poziomem stresu.

Słowa kluczowe: dobrostan zwierząt, system utrzymania, odporność, świnia, stres