



Effect of Pelleted and Chopped Wheat Straw on the Footpad Dermatitis in Broilers

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ABSTRACT

An experiment was conducted to determine whether it is possible to replace the chopped wheat straw with newly formulated pelleted straw taking into account the prevalence and severity of footpad dermatitis (FPD) in broiler chickens. The study included 300 one-day-old Ross 308 broilers. One group of broilers was reared on chopped wheat straw (the particle length of straw ≥ 10 cm). The second group was kept on newly formulated pelleted wheat straw. The duration of the trial was 42 days. Moisture content in litter materials and FPD occurrence and severity were assessed weekly. First signs of FPD were observed in 21-day old chickens reared on chopped wheat straw (FPD score = 0.52 ± 0.10) and a week later in a group of birds kept on pelleted straw (FPD score = 0.34 ± 0.07). At the end of the experiment in both groups of broilers percentage of severe FPD was high. Severe lesions were significantly ($p < 0.01$) more frequent (80%) in broilers reared on chopped wheat straw than on pelleted straw (56%). Although the high moisture content was measured in both litter substrates and the high frequency of severe FPD was estimated in both groups of broilers, pelleted straw showed lower moisture content, occurrence and severity of FPD (2.56 ± 0.19) comparing to chopped wheat straw (3.20 ± 0.13) at the end of the experiment. Further research can be directed to the technological improvement of chopped and pelleted straw production or into the improvement of handling with this substrate.

INTRODUCTION

There are numerous factors detrimentally affecting health and welfare of broiler chickens (Bessei, 2006; Arnould and Leterrier, 2007; Robins and Phillips, 2011; Dawkins and Layton, 2012). Many of them cause leg problems including those of infective, developmental and degenerative etiology. In their severe forms many of these disorders are painful and disable broilers to walk normally and to approach to feeders and drinkers. Inability to walk and to express normal behaviour frustrates broilers. Inability to approach to feeders and drinkers may be the cause of broiler starvation (Bradshaw *et al.*, 2002). The most widespread degenerative leg disorder in broilers is contact dermatitis.

Beside footpad dermatitis (FPD) or plantar pododermatitis and hock burns (HB) it also embraces breast blisters or burns (Berg, 2004). All of these three different types of the same condition occur due to prolonged contact of these areas with litter with a high content of moisture and irritants such as ammonia (De Jong *et al.*, 2014; Taira *et al.*, 2014). Therefore, contact dermatitis usually correlates to suboptimal litter conditions as an input factor and resource-based indicator of bird welfare (Bassler *et al.*, 2013). On the other side, it correlates with bird welfare, carcass quality, meat quality, meat safety and economy of poultry industry as outputs (Broom and Reefmann, 2005; Shepherd and Fairchild, 2010; Hashimoto *et al.*, 2013). Nowadays, the incidence and severity of contact dermatitis are used as a welfare assessment measure in commercial broiler production systems (Butterworth, 2013). In broiler flocks, FPD is more prevalent than HB. The prevalence of breast burn in flocks is very low (Haslam *et al.*, 2007;

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Authors' Contributions

VA and MV conceived and designed the study; and also were involved in the interpretation of data related to the production results and FPD score. MV also controlled health status of broilers during the whole time of the experiment. JA substantially contributed in sampling, analysis and interpretation of data related to air and litter quality. RR participated in drafting the article. DMS statistically analysed all data.

Key words

Broiler, Footpad dermatitis, Chopped wheat straw, Pelleted wheat straw.

Allain *et al.*, 2009). In fast-growing broiler strains, the first signs of FPD and HB may be expected in the second week of the rearing cycle (Kjaer *et al.*, 2006; Hepworth *et al.*, 2010, 2011). Although, contact dermatitis is caused by water and other chemical substances in the litter there are many other risk factors that predispose broilers to this condition (Martrenchar *et al.*, 2002). However, the ability of the bedding material to absorb and quickly release moisture may be the most important characteristics (Bilgili *et al.*, 2009). Various types of bedding materials are used in different geographical regions. It is mainly locally available materials of organic origin. Chopped wheat straw and wood shavings are two materials mainly used as bedding materials in broiler production in Serbia. It was also confirmed that the prevalence of FPD in broilers is the highest on wheat straw compared to other types of litter (Martrenchar *et al.*, 2002; Meluzzi *et al.*, 2007; Berk, 2009; Nowaczewski *et al.*, 2011; Mihai *et al.*, 2013; Musilova *et al.*, 2013; Kyvsgaard *et al.*, 2013; De Jong *et al.*, 2014; Škrbić *et al.*, 2015; Terčić *et al.*, 2015). Therefore, the aim of the study was to determine whether it is possible to replace the chopped wheat straw with newly formulated pelleted straw taking into account the prevalence and severity of FPD in broilers.

MATERIALS AND METHODS

Ethical statement

Approval of the Ethical Council of Serbian Ministry of Agriculture under the number 323-07-11326/2015-05 was obtained for this experiment prior to the commencement of the study.

Experimental facility

The study was performed in the experimental housing facility for poultry at the Faculty of veterinary medicine in Belgrade, Serbia. There were two identical pens with concrete floor and the same type of ventilation. Dimensions of each room were 300 × 296 cm. Electrical heaters were individually placed in each pen to maintain a temperature of 32° C in the first two days of the experiment, with a reduction of 1° C every 2 days to reach a final temperature of 23° C. Each room had natural ventilation composed of two windows (110 x 115 cm) on one of a lateral side and a door on an opposite side (74 x 190 cm).

Bedding material

Two types of bedding materials were used in the study – chopped and pelleted wheat straw. Both types of bedding materials were obtained from the same manufacturer. Pelleted wheat straw is the new material produced from wheat straw pressed into pellets at a high temperature of 90° C. The floor of the first pen was covered with chopped

wheat straw (the particle length of straw ≥ 10 cm) in the amount of 2.2 kg/m². The floor of the second pen was covered with pelleted straw (6 kg/m²). The initial depth of bedding materials was 15 and 3 cm for chopped and pelleted wheat straw, respectively. The amount of pelleted wheat straw was added according to the manufacturer recommendations. Chopped wheat straw was added in a quantity to reach a depth of 15 cm. This corresponds to conditions of the commercial broiler production in Serbia. The manufacturer provided the initial data on prices, physical and chemical characteristics of chopped and pelleted wheat straw that are given in Table I.

Table I.- Main experiment characteristics.

	Group 1	Group 2
Animals		
Animals genotype	Ross 308	Ross 308
Number	150	150
Duration of experiment	0 - 42 day	0 - 42 day
Housing facilities and environmental conditions		
Room width x length (cm)	300 x 296	300 x 296
Room high	300	300
Floor type	Concrete	Concrete
Stocking density (birds/m ²)	17	17
Ventilation	Natural	Natural
Air velocity	< 0.4 m/s	< 0.4 m/s
Number of windows	2	2
Dimension of window (cm)	110 x 115	110 x 115
Number of doors	1	1
Door width x high (cm)	74 x 190	74 x 190
Bedding material		
Type	Chopped wheat straw	Pelleted straw
Initial quantity	2.2 kg/m ²	6 kg/m ²
Initial depth (cm)	15	3
Cost (€/kg)	0.05	0.1
pH value	6.5	6.9
Initial moisture (%)	9.18	10.02
Water holding capacity (%)	290%	215%
Water releasing capacity (%)	45%	55%
N (%)	0.25	0.50
C (%)	45.33	43.23
H (%)	7.42	7.73
S (%)	0.27	0.15
Final quantity of litter material at the end of experiment	335.1 kg	426.7 kg

Animals

Three hundred one-day-old Ross 308 broiler chickens of both sexes were placed in two pens with 150 chickens in each. Initial stocking density in both pens was 17 birds/m². At the end of experiment stocking density in group with chopped wheat straw (control group) was 17 birds/m² (36.41 kg/m²) and in group with pelleted wheat straw (experimental group) 17 birds/m² (36.43 kg/m²). Birds were reared to 42 days of age (September – November 2015) on a three-phase commercial feeding program consisting of a starter (0-14 d), grower (15-28 d), and finisher (29-42 d) feeds. Feed and water were available ad libitum using bell feeders and drinkers.

Measurements

Every week 50 randomly selected broilers were measured on body weights (BW) and assessed on the presence and severity on FPD. Evaluation of FPD was carried out on both, the right and the left footpad of each individual bird. The extent of lesions on footpads was assessed using the 5-point scale for visual observation scoring of pododermatitis. The scale increases from category 0 (no evidence of FPD) to category 4 (severe evidence of FPD). Within an individual, the injury category was based on the foot with the most severe dermatitis. All birds were evaluated by a single observer throughout the experiments. The mean score of FPD was calculated as the cumulative total of the lesion scores divided by the total number of birds examined. Pododermatitis frequency at the group level are given in percentages after summation birds with FPD score 1 and 2 and grouping them into the category of the moderate form and birds with score 3 and 4 into the severe form of FPD according to the methodology given in Welfare Quality® assessment protocol for poultry (Welfare Quality, 2009).

Litter samples from both pens were collected and analyzed for percentage of moisture weekly. Litter was collected from the 4 corners and center of each pen including the litter from under the drinkers in the amount of 100 g per site of collection. Samples were obtained from the full depth of the litter. Litter samples from each pen were pooled and mixed in plastic bags to create a composite sample for a laboratory analysis. The total amount of 100 g subsample of mixed samples from each pen was sent to the laboratory. In order to estimate moisture content samples were oven-dried at 105°C for the time needed to reach weight loss stability.

In both rooms air temperature, air velocity and relative humidity were measured at bird level by Lutron LM-8010 climameter (Lutron Electronic Enterprise, Taiwan).

Statistical analysis

Results were analysed by standard statistical methods,

expressed as mean ± standard deviation (SD) for broiler BW and as mean ± standard error (SE) for footpad score and graphically presented using Microsoft Office Excel program. The significance of the differences between the two groups of broilers kept on pelleted or chopped wheat straw was determined by Student's t-test. Differences were considered significant at $p < 0.05$.

RESULTS

Results of BW in broilers reared on two different types of wheat straw litter are shown in Table II. There were no significant differences in BW between broilers reared on pelleted and chopped wheat straw at the day 42.

Table II.- Broiler body weights (g).

Day	Pelleted wheat straw	Chopped wheat straw
0	45.06±2.84 ^a	45.84±3.07
7	202.72±24.42	204.36±21.89
14	521.34±45.34	542.30±50.83
21	945.24±143.50	937.68±163.26
28	1431.92±200.72	1480.38±205.63
35	2050.28±260.77	1960.50±216.27
42	2156.68±241.52	2155.80±266.39

^a, Mean±SD.

Table III.- Footpad score.

Day	Pelleted wheat straw	Chopped wheat straw	p
0	0	0	
7	0	0	
14	0	0	
21	0	0.52±0.10	
28	0.34±0.07 ^a	1.16±0.12	<0.01
35	0.92±0.12	2.70±0.15	<0.01
42	2.56±0.19	3.20±0.13	<0.01

^a, Mean±SEM.

Footpad score is given in Table III. From data given in that table it is evident that there were differences in the time of FPD occurrence in broilers reared on two different types of litter. So, first signs of FPD were observed in 21-day old chickens reared on chopped wheat straw (0.52±0.10) and a week later in chickens on pelleted straw (0.34±0.07). With time, footpad score increased in both groups of birds and reached the average value of 2.56±0.19 in broilers on pelleted wheat straw comparing with significant higher ($p < 0.01$) foot pad score in broilers reared on chopped wheat straw

(3.20±0.13) at the end of the experiment. Between two groups of broilers, there were also significant differences in footpad score at the day 28 and 35 ($p<0.01$).

At the day 42 significant differences ($p<0.01$) were estimated in the frequency of FPD between broilers reared on pelleted straw and those on chopped straw (Table IV). Although in both groups of broilers percentage of severe FPD was high, it was estimated that serious lesions were significantly more frequent (80%) in broilers reared on chopped wheat straw ($p<0.01$). A severe form of FPD in both broiler groups can be seen in Figure 1 (Fig. 1a – chopped straw bedding; Fig. 1b – pelleted straw bedding).

Table IV.- Percentage of birds with footpad dermatitis at the end of study (%).

Individual score	Pelleted wheat straw	Chopped wheat straw	p
0 (No FPD)	8	0	
1+2 (Moderate FPD)	36	20	
3+4 (Severe FPD)	56	80	<0.01

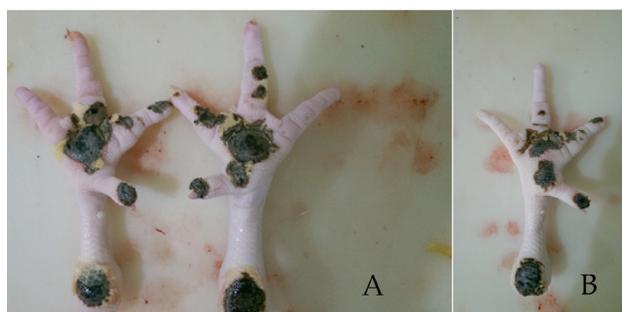


Fig. 1. Severe footpad dermatitis and hock burns form in broilers kept on wheat straw; a, chopped straw bedding; b, pelleted straw bedding.

Figure 2 shows the moisture content in two different type of litter. In a litter of chopped wheat straw, moisture content raised from 9.58 to 70.21 % while the highest moisture content in pelleted wheat straw was 62.7 %. Considering results given in Table III and Figure 2 it is clear that the occurrence of FPD in both groups of broilers was observed when moisture content in both litter types exceeded a value of 35 %. It was in the third week of the trial in broilers reared on chopped straw when the moisture content was 35.05 % and in the fourth week in birds reared on a litter of pelleted wheat straw when the moisture content was 44 %.

Air temperature and relative humidity in both pens are given in Fig. 3. The average value for the temperature at the beginning of the experiment was 32.8 and 33.1° C

in the room with broilers reared on chopped and pelleted straw, respectively. The temperature slowly decreased in both rooms to the end of the experiment so the average value at the day 42 was 21.86 and 19.9° C in the room with broilers kept on chopped and pelleted straw, respectively. However, relative humidity raised in both rooms as shown in Fig. 3 and reached the average value of 76.93 % and 74.83 % in the room with chopped and pelleted straw, respectively.

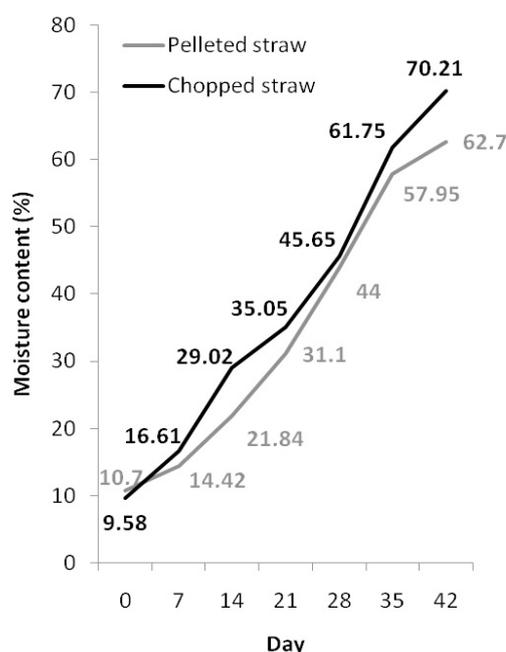


Fig. 2. Moisture content (%) in two types of wheat straw.

DISCUSSION

Poultry bedding material has to meet a numerous criteria since bedding has many roles and significant impact on broiler production (Robins and Philips, 2011). These criteria include cost, availability, easiness of handling, the possibility of reuse, absorption capacity, the ability to avoid compacting, environmental impact, low fermentation, performance and production results including carcass quality (Garcia *et al.*, 2012). All of these facts motivated many scientists to study how different types of bedding materials affected welfare including prevalence and severity of FPD in broilers (Bilgili *et al.*, 2009; Nowaczewski *et al.*, 2011; Mihai *et al.*, 2013; Musilova *et al.*, 2013; Taira *et al.*, 2014; Škrbić *et al.*, 2015). All of them estimated that frequency and severity of FPD were higher in broilers reared on wheat straw comparing with other types of bedding materials. Results that are obtained in our study confirmed previous findings

of those authors. In our discussion, we mainly oriented on studies conducted in the region or on results that are obtained in countries that wheat straw is dominant bedding material in broiler industry. However, there is a lack of scientific data on pelleted straw as a bedding material in broilers. Similar investigation to our study was conducted in Germany. It was observed that broilers kept on pelleted straw had the best foot pads and the highest BW compared to other bedding materials in that study. Together with this conclusion, it was estimated that chopped straw was the least suitable variant as bedding material (Berk, 2009).

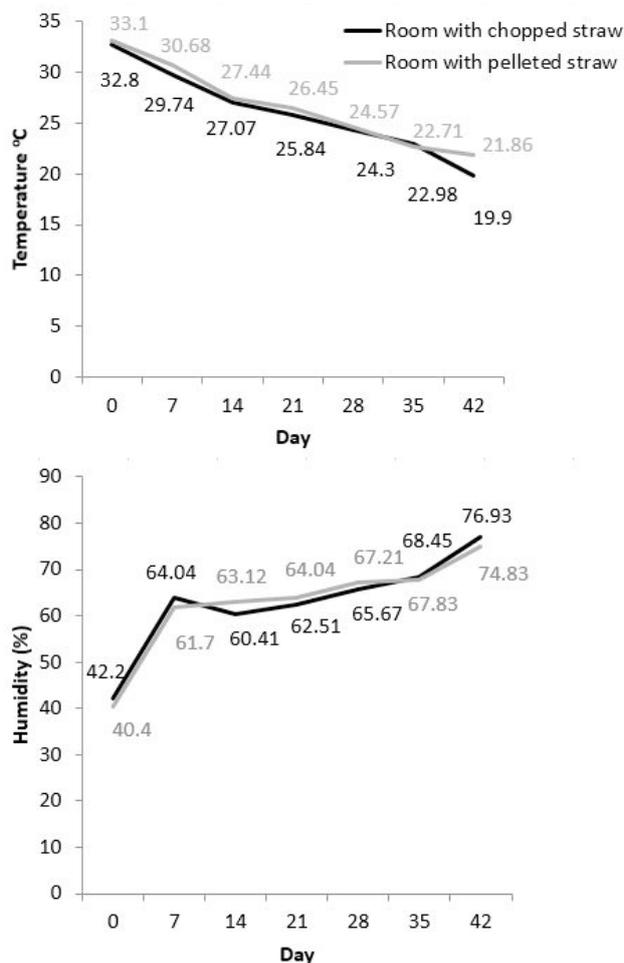


Fig. 3. Air, temperature and relative humidity in pens.

Other authors from Serbia also studied FPD in the Ross 308 genotype on two different bedding materials including wheat straw (Škrbić *et al.*, 2015). They estimated that the Ross 308 broiler genotype showed a greater tendency to develop FPD. The moisture content in the litter of wheat straw was higher in our experiment than in experiment of these authors. It is probably due to higher

stocking density in our experiment than in experiment of Škrbić *et al.* (2015). FPD score in our experiments also was higher. Therefore, one of the main measures to reduce the occurrence and severity of FPD may be a reduction of stocking density (Ekstrand *et al.*, 1998). Final BW of broilers was similar in our study comparing to study of Škrbić *et al.* (2015). However, these authors (Škrbić *et al.*, 2015) did not confirm that litter moisture content had an influence on the development of contact dermatitis in broilers.

Authors from Slovenia also published results that related to the influence of different bedding materials on the occurrence and severity of FPD in broilers (Terčič *et al.*, 2015). So, the highest moisture content and the highest severity of FPD has estimated in birds reared on the litter of chopped straw. In our study, it was estimated that FPD in severe forms was present in 80 % of broilers reared on chopped wheat straw and in 56% of broilers on pelleted wheat straw at the day 42. Similar results that related to the frequency of the severe FPD forms were obtained by other authors (Bessei, 2006; Meluzzi *et al.*, 2007; Mihai *et al.*, 2013; Musilova *et al.*, 2013). Further, an investigation conducted in France confirmed that FPD prevalence was higher in broiler chickens reared on chopped straw than on pelleted straw under the field condition (Martrenchar *et al.*, 2002). Scientists from Romania also use the genotype Ross 308 in the study of litter influence on FPD and BW in broilers (Mihai *et al.*, 2013). In their study, the incidence of FPD in broilers was same as in our trial. However, they used the whole wheat straw as a bedding material in their experiment. At the day 42 BW of broilers in their experiments was slightly higher than in our study. They proved that litter type influences in a great extent the FPD score and BW of broiler chickens contrary to Musilova *et al.* (2013) who concluded that FPD did not affect production results of broilers. In our study both broiler groups had poor weight gain between the day 35–42, much slower growth than ROSS 308 performance objectives. It is assumed that both groups had suffered substantial stress during that period. It might be a consequence of the severe form of pododermatitis and broiler inability to approach to feeders due to painful injuries on their legs.

Considering the time of FPD occurrence our results differ from results of other authors who estimated that first lesions on footpad occurred earlier in the second week of broiler age (Bilgili *et al.*, 2009; Taira *et al.*, 2014). On the other hand, results obtained in our study is in agreement with results obtained by Taira *et al.* (2014) in relation to the occurrence of FPD in broilers reared on a litter with high moisture content. It means that together with litter moisture content increase, the severity of FPD also increased. However, these authors the first signs of

FPD observed at 14 days of age of broilers on wet litter. In broilers that they reared on dry litter, the first signs of FPD were observed at 28 days of broiler age. In our study, the first signs of the moderate FDP form occurred also at 28 days of age of broilers kept on the pelleted straw when moisture content reached the value of 44%. The main reason why FPD firstly occurred in broilers on chopped straw than in those on pelleted straw may be found in the explanation given by Bilgili *et al.* (2009) who assumed that bedding materials with sharp edges such as chopped straw may contribute to FPD through their abrasive action. Also, it is very interesting that another group of authors from Serbia estimated that broilers reared on chopped straw had significantly better leg condition and smaller incidence and severity of FPD than birds reared on whole straw (Djukić Stojčić *et al.*, 2016). Contrary to these authors, Nowaczewski *et al.* (2011) found that boilers kept on chopped straw were characterised by the worst leg health condition. Our results confirm this finding. Finally, in the genotype Ross 308 the presence of biomarkers for FPD development recently is confirmed (Chen *et al.*, 2016).

Main reasons for differences between results obtained in our study compared with results of other authors may be the genotype of broilers, seasons when trials of other authors were conducted, differences in stocking density, litter management and the method used for FPD scoring. Lack of data on litter management during trials is evident in many published papers. For example, it is not clear if the new amount of bedding materials was added and how often or litter was just turned if it was necessary and how often. During our study, new amounts of bedding materials were not added and litter was not turned. Therefore, it is possible that these deficiencies were the main reason for high moisture content in both forms of straw litter and also for the high frequency of FPD in both groups of broilers.

Although many factors influence moisture content in the litter, microclimate and housing factors contribute most acutely to wet litter (Dunlop *et al.*, 2016). Important parameters of the facilities microclimate are air temperature and relative humidity. Results that related to the air temperature and relative humidity in our study show that relative humidity in both pens rose similarly as moisture content in both types of litter. Average values that related to the air relative humidity are relatively higher than desired levels for Ross 308. In another study, it was estimated that low BW of Ross 308 broiler chickens might be due to inadequate environmental conditions in bird houses (Akyuz, 2009). Constant increasing in air relative humidity as well as in litter moisture content during our experiment might be a consequence of insufficient ventilation in both pens. Previously, it was estimated that relative humidity of 75% was sufficient to cause wet litter

(Weaver and Meijerhof, 1991). An investigation conducted on broiler farms in the UK disclosed that side ventilation where the air was drawn into the pen on one side and extracted from the opposite side contributed to wet litter (Hermans *et al.*, 2006). The same type of ventilation was in pens where broilers were kept in our experiment.

CONCLUSION

From results obtained in the study, it can be concluded that newly formulated pelleted wheat straw as litter substrate shown lower moisture content, occurrence and severity of FPD comparing to chopped wheat straw. The form of straw (pelleted or chopped) as bedding material did not influence differences in BW between two groups of broilers.

Although the high moisture content was recorded in both forms of litter substrate, chopped wheat straw was less suitable as bedding material for broiler production from the aspect of bird welfare. However, chopped wheat straw is currently the most popular bedding materials in Serbia. It is easy to obtain and a price is low. Although the production of pelleted straw is twice more expensive than chopped straw it is of importance to continue the research because the production of pelleted straw is primarily driven by local recycling efforts and new market development. It is estimated that the total cost for chopped straw in quantity to cover the floor area of 8.88 m² to the depth of 15 cm was only one euro. On the other hand, that the total cost for pelleted straw to cover the same area to the depth of 3 cm was 5 euro. It means that the initial price of pelleted straw was twice higher, but the overall amount needed five times more money comparing with chopped straw. In further researches it is necessary to estimate whether it is economically justifiably to use pelleted litter in broiler production, taking into account its cost and association with diseases, ammonia production and FPD. Therefore, further studies could be continued in several directions. Firstly, it is necessary to determine whether there are other technological methods to improve the quality of chopped and pelleted straw by adding some other materials. Secondly, it is important to estimate the adequate initial and total amount and depth for both materials and finally, to estimate the adequate handling practice with these litter types especially taking into account microclimate and housing condition during broiler production.

Ethical approvals

Experiment was approved by the ethics committee of the Faculty of Veterinary Medicine and Ministry of agriculture and Environmental Protection Republic of Serbia (323-07-11326/2015/05).

Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this article

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