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The effect of a bedding materials on performance, welfare and behavior of broiler chickens: A review

Vplyv podstielkových materiálov na užitkovosť, welfare a správanie kurčiat výkrmového typu: Prehľad literatúry

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ABSTRACT

Bedding material has a significant effect on life, health and production of broiler chicken since they are in direct contact with litter. When condition of litter is poor, it increases an occurrence of pododermatitis. Birds living in chronic pain move less and consequently eat and drink less and because of that their production is less efficient. The aim of this review is to compare different bedding materials used in Europe and elsewhere in the world and to evaluate their effects on production parameters, health and animal welfare. During the last years, a lot of research has been done using both traditional and alternative bedding materials. A significant part of materials was evaluated as suitable or improving production parameters. There is an evidence that at least one quarter of broiler chicken live in constant pain due to footpad dermatitis, joint inflammations or other locomotory disorders for more than one third of their live. The health of the locomotory system is the major challenge for improving poultry welfare. Several substrates can be used as bedding material for poultry. In general, we can conclude that, the finer particles are the lower is the occurrence of pododermatitis. However optimal bedding material must be able to absorb excess water but also to be dried properly. Another important aspect of animal welfare is the opportunity to manifest their natural behaviour. Research clearly shows that poultry prefer to perform dustbathing only in dry and dusty substrate.

Keywords: poultry, litter, pododermatitis, footpad, straw, peat

ABSTRAKT

Podstielkový materiál významne vplýva na život, zdravie a produkciu brojlerových kurčiat nakoľko sú s ním v priamom kontakte. Pokiaľ je stav podstielky zlý, zvyšuje sa možnosť vzniku pododermatídy. Vtáky pociťujúce chronickú bolesť sa menej hýbu a nadväzne na to aj menej žerú a pijú, čo má za následok nižšiu efektivitu produkcie. Cieľom tohto prehľadu je porovnať podstielkové materiály používané v Európe aj vo svete a posúdiť ich vplyv na parametre úžitkovosti, zdravie a welfare zvierat. V posledných rokoch bolo vykonané množstvo experimentov s použitím tradičných aj alternatívnych materiálov. Publikovaných bolo viacero pokusov s použitím rôznych podstielkových materiálov. Značná časť z nich bola zhodnotená, ako vhodná pre hydinu, či dokonca zlepšujúca produkčné parametre. Je preukázané, že najmenej štvrtina brojlerových kurčiat žije v stave konštantnej bolesti vzhľadom na pododermatídu behákov, zápaly kĺbov alebo iné poruchy pohybového aparátu po dobu viac ako tretiny života. Zdravie pohybového ústrojenstva je, preto jednou z kľúčových výziev na zlepšenie welfare hydiny. Množstvo substrátov môže byť použitých ako podstielkový materiál pre hydinu. Vo všeobecnosti platí, že čím jemnejšie sú častice, tým menšia je možnosť výskytu pododermatídy. Optimálny podstielkový materiál musí byť však schopný dobre prijímať vlhkosť no byť aj ľahko sušiteľný. Ďalším dôležitým aspektom z pohľadu životnej pohody zvierat je schopnosť prejavovať prirodzené správanie. Výskumy jasne preukazujú, že hydina preferuje popolenie v suchom a prašnom materiály.

Kľúčové slová: hydina, podstieľka, pododermatída, behák, slama, rašelina

INTRODUCTION

There are many litter materials used in the broiler industry around the globe. Farm managers often choose the material depending on its price and availability. Pine shavings are the most common bedding material in the United States, while in Eastern and Central Europe it is mostly straw. We can look at the various properties of bedding materials from several perspectives. While broiler farms often use straw due to its good availability and low price, parent stock farms often use high quality wooden shavings, mainly for hygienic reasons. Poorly stored straw can be a source of salmonellosis or aspergillosis (Roberts, 2009). There is a growing public interest in farming conditions and animal welfare in general. At the same time, possibilities of selling chicken paws to Asian countries are opening increasingly. For these reasons, some companies are beginning to look for ways to improve the quality of life of chickens as the health of chicken paws as a trading article. The right choice of bedding material can also be a crucial factor in their efforts (Shepherd and Fairchild, 2010). In addition to commonly available materials and materials improving the health of footpads, academics as well as professionals are looking for another alternative bedding materials which are mostly various by-products or wastes. However, their real possibilities of application are questionable.

From a practical approach, the ability of the bedding material to absorb moisture and consequently to release moisture during drying is especially important. Some materials are more prone to forming hard cakes of solidified material on the surface of the litter. The most used bedding materials in Europe include whole or chopped straw, wood shavings, peat and straw pellets. We present them in Figure 1 (Gussem et al., 2013; Tůmová et al., 2019).

EFFECT OF BEDDING MATERIAL ON PERFORMANCE

The condition of the bedding material, the productivity of the animals, the occurrence of pododermatitis and animal welfare are closely related. For the chicken to feel comfortable and fulfill their growth potential, the following must be complied:

"Protect broilers from damage and provide a dry warm covering to the floor by using adequate quantities of a good–quality litter material. Avoid nutritional causes of wet litter. Ensure adequate ventilation and avoid excess moisture. Choose a litter material that is absorbent, non-dusty, and clean. Litter should be readily available from a reliable source. Use fresh litter for each crop to prevent reinfection by pathogens. Litter storage facilities should be protected from the weather and secure from access by vermin and wild birds" (Aviagen, 2018).

High moisture of the bedding material increases ammonia build-up through increased microbial metabolism, resulting in respiratory and eye lesions, which negatively affect birds' welfare and productivity. Dustiness from extremely dry bedding materials or very fine particles may also predispose birds to respiratory problems, resulting in higher mortality. Very large and coarse bedding materials may, however, downgrade carcass quality due to their abrasive effects to foot pads (Diarra et al., 2021).

There are many external factors which can negatively affect the quality of litter. One of them is a high stocking density. The higher the density, the more difficult it is to keep the liter in good condition. Another key factor is correct nutrition, especially the correct salt content and fat quality. An increased level of sodium above 0.15% increases the humidity of litter and consequently the development of lesion of footpads. (Cengiz et al., 2012). Many diseases causing enteritis and consequently diarrhea can rapidly decrease litter condition because of excess water. Lastly, a good setting of drinking lines and proper ventilation are important factors (Aviagen, 2018).

The results of scientific experiments differ in the effects of different materials in terms of improving technical results. According to some authors, the direct effect on performance has not been proven or is very low (Lien et al., 1992; Bilgili et al., 2009; Cengiz et al., 2011). Another group of authors proved in their research a positive effect of different litter materials on performance.

Figure 1. Different bedding materials used on Slovak farms: a) wheat straw, b) wood shavings, c) peat, d) wheat pellets

Straw, wood shavings and pellets

Kheravii et al. (2017) proved a positive effect on feed conversion ratio (FCR) using straw pellets. In their previous research, they observed that until day 10, there is a positive effect of pelleted straw on body weight (BW) of the birds but not thereafter. They also observed a positive effect of this material on FCR compared to wood shavings and paper (Kheravii et al., 2015). Aviagen (2018) also recommend this type of bedding because it has a bigger water holding capacity than straw and shavings and cakes less easily than sawdust.

According to the research of El-Deek (2011) using a combination of bedding materials can be beneficial. They found out that use of barley straw + wood shaving and

wood shaving + paper has a positive effect on broiler BW and average weight gain (AWG). Ramadan et al. (2013) who also studied different combinations of bedding material found out that birds reared on wood shavings + sand manifested better AWG and BW than these reared on straw + sand. Interesting is that they did not find any difference when litter was used separately. When comparing sawdust, straw, rice husks and sugarcane bagasse, there was not an effect on performance except a there may be the lowest mortality using sawdust.

Wood based bedding material may increase production parameters (AWG, BW, FCR and survivability) compared to plant-based or inorganic materials (Munir et al., 2019). Wood based bedding materials can be made of softwood or hardwood and be in the form of sawdust, shavings, chips or bark. Hardwood shavings are often high in moisture and therefore can contain mold if not properly stored. From this point of view softwood shavings are safer but, in many areas, there is a shortage of this material, and it is impropriety expensive. Hardwood chips can negatively affect the occurrence of breast blisters. Bark can be used but they should be medium size (Aviagen, 2018).

Wood shavings as well as sand have the positive effect on BW, AWG and FCR compared to bean straw, wheat straw and rice husks (Abougabal et al., 2022). Bilgili et al. (1999) in their older research did not observe any effect on performance except of abdominal fat yield (which was lower using sand compared to shavings) and occurrence of coliforms bacteria as *E. coli*. In addition to these materials, Benabdeljelil and Ayachi (1996) also compared ground wheat straw, rice straw and rice husks in their research. They showed no effect on performance or incidence of locomotory abnormalities.

Alternative materials

Grass hay stored outside in polyethylene wrap for 2 seasons may negatively affect BW, AWG as well as FCR of the birds during a starter and grower phase. During later stages of the cycle this effect is not so significant. According to Purswell et al. (2020) it is due to reduced intake of the litter by chicken during later stages.

Cellulose-based by-products mixed with shaving perform comparatively to pine shavings in terms of BW, AWG as well as FCR (Ritz et al., 2016).

Leaves that would normally be composted in a municipal landfill can also be used as bedding for chickens. In the experiment done by Willis et al. (1997) leaves were compared with shavings, and no difference in weight or feed conversion was observed. However, the hygiene of this material should be considered. It is possible to include a smaller amount of dehydrated grass in the litter in combination with wood shavings. Up to 25%, this inclusion does not degrade the properties of the material or the performance of animals.

In theory, processed paper can also be used as bedding, but it is difficult to keep it dry and it forms cakes on the surface (Aviagen, 2018). However, paper can be pelletized. Frame et al. (2002) conducted research on turkeys using paper pellets. We assume that the results could be relevant also to chickens. Growth on paper pellets was identical to performance on shavings and mortality was lower when paper product was used.

Materials used tropical and arid environment

Many academics from tropical and subtropical areas explored also using local materials as an alternative to straw or shavings.

Huang et al. (2009) found that there is a higher FCR bud also higher daily gain on birds raised on coconut hulls compared with shavings. Swain and Sundaram (2000) used in their research a coir dust of coconut husk. Despite some producers seeing it as an alternative to peat, they did not find neither positive nor negative effect on performance while using this by-product. Coconut husks are cheap and easily available material in coconut producing areas. It tends to make cakes but works well when responsibly managed (Aviagen 2018).

Chamblee and Yeatman (2003) tried to use rice hull ash and its combinations with other litter materials and did not find any negative effect on the performance of the birds. According to Aviagen (2018) rice hulls can be used when price is attractive but there are two major

risks. Chickens sometimes tend to eat them and their water holding capacity is relatively low.

Atapattu and Wickramasinghe (2007) evaluated the use of refused tea as bedding materials also without any negative effect on birds. However, they only moved chickens to the tea bedding material at the age of 20 days. However, footpads are most sensitive during the first weeks of life.

Sand can be used in humid areas where humidity is low. The sand level should be relatively low to not make it difficult for the chicken to move. If sand is used, good preparation of the barn and proper preheating is essential as it can quickly cool down and get wet (Aviagen, 2018). Hafeed et al. (2009) did not prove any effect on the productivity comparing sand with straw and shavings.

Wheat straw, clover straw and sugarcane top chips showed a positive effect on BW and AWG compared with cornstalk chips and chopped palm spines. Clover straw had the highest positive effect on FCR compared with bedding materials mentioned above (Farghly et al., 2021).

Supplementation of neem leaves (*Azadirachta indica*) in 2-6% to wood shaving might have a beneficial effect on BW, FCR and AWG (Bishnoi et al., 2021).

Researchers from South America compared chopped soybean straw, among other materials. However, they did not find any demonstrable negative or positive effect on productivity (Avila et al., 2008).

Other material used outside of Europe are peanut hulls. They are available in areas of peanut production and relatively cheap. However, they are susceptible to mold growth, increase the risk of aspergillosis, and sometimes contain pesticides (Aviagen, 2018).

EFFECT OF BEDDING MATERIAL ON HEALTH OF FOOTPADS

However, because birds are in direct contact with the litter, the choice of bedding material is undoubtedly one of the key factors that influences the occurrence of necrotic lesions on plantar surface of the footpads - footpad dermatitis (FPD). When FPD lesions transform into deep ulcers, they cause pain and discomfort for broilers. Due to the pain, the chickens may move less and consequently eat less, which reduces their performance (Andrews and McPherson, 1963; Gussem et al., 2013). A clear negative correlation between FPD and performance (BW and leg meat yields) was demonstrated by Hoshimoto et al. (2013) which confirms that if litter quality is improved it can reduce an occurrence of FPD and consequently improve production parameters.

The etiology of FPD is a complex interaction of several factors such as litter quality, stocking density, sex, digestive tract health, microclimate, target BW as well as management of drinkers (Bilgili et al., 2009). Proper management of drinking lines and microclimate in the shed has the major effect on FPD compared to nutrition and diseases. But there are specific cases when diseases like coccidiosis can affect the quality of bedding material significantly (Dunlop, 2016). Gussem et al. (2013) also states that the reduction in litter quality can be related to both poor ventilation and gut problems (excess urine in feces). According to Abraham et al. (2021), litter moisture has the crucial effect on severenity of FPD, but they also found that orange corn, containing antioxidants and carotenoids, reduces FPD and improved AWG of broiler chicken. According to research of Taira et al. (2013) if broilers are kept on wet bedding, the first lesions appear at day 14 and from 21. day their incidence increases rapidly. If the bedding is dry, the first lesions appear only after 28. day and are suppressed.

The most important welfare challenge in the commercial production of broiler chicken is “leg weakness” caused by the genetic selection for rapid growth and hypertrophy of the breast muscle. There is evidence that disorders of bones and joints cause a pain and almost one quarter of heavy strains of broiler chicken live in chronic pain for at least one third of their lives (Webster, 2008).

The health of chicken paws is important also for two economic reasons. Large and clean chicken paws without injuries can be now sold to Asia. The second important economic factor is that many slaughterhouses and state institutions have begun to use lesions on footpads, hocks

and breasts to assess welfare level. In some western countries, due to the high incidence of lesions, it is possible to lose farming licenses, elsewhere there is a risk of fines or a reduction in the price from slaughterhouses. There are several systems for scoring lesions on foot pads. Shepherd and Fairchild (2010) state that one of the most used is the Swedish scoring system. It divides footpads into 3 categories according to the occurrence of lesions. In Figure 2 there is an example of different degrees of damage of footpads.

Effects of different materials on FPD

De Jong et al. (2014) confirmed by research that there is a strong effect of FPD caused by wet litter on the performance of the birds and their welfare. In their research they clearly linked a higher FCR, lower water intake and lower BW gain with a FPD caused by wet litter after day 28. In addition, they declared that occurrence of FPD reduces a mobility of the birds cause also hock burns and breast blister and has significant negative effect on the birds.

Peat is beneficial to the health of footpads and hock skin health compared to straw and shavings with straw reduced the occurrence of FPD compared with wood shavings. To use the advantages of this material it must be kept in good condition (Kaukonen et al., 2017).

According to Kheravii et al. (2017) there is much lower incidence of FPD in broilers reared on pelleted straw compared with other usual litter materials. Another research, including pelleted straw, evaluated the effect of adding medical plants into straw pellets on pathogens in poultry litter. They proved a decrease of mesophilic bacteria and yeasts (Gontar, 2022).

Zikic et al. (2017) observed lower occurrence of FPD in broilers reared on chopped straw compared with whole long straw. The same conclusion was reached by Đukić Stojčić et al. (2016). In addition to comparing chopped and whole straw, they also assessed the effect of enzymatic bacterial product - Micropan® which lowered the pH of the litter and had a positive effect on the health of footpads.

Cengiz et al. (2011) performed a trial with pine shavings and stated that a particle size of a litter material has a crucial effect on the occurrence of FPD. Popescu et al. (2018) claim that a sunflower seed hull caused less lesions and FPD than a chopped straw during a trial done on two commercial farms. Adding cellulose-based by products has a positive effect on footpad health in early stages of the growth but in later stages this effect is not significant (Ritz et al., 2016).

Figure 2. Footpads with score 0,1 and 2

Parsons and Baker (1985) evaluated the effect of softwood chopping fines as a litter compared with pine shavings. The main production factors were not affected but there was less FPD and less breast downgrades. However, mortality was slightly higher using finer litter. Their findings support observations of Cengiz et al. (2011) that a particle size has a critical effect on FPD.

Contrary to the previous observations Ramadan and El-Khloya (2017) claim that a type of bedding material does not have any effect on birds' wellbeing and footpad score. Their observation may be however affected by the very dry environment in the area where they performed their trials.

Onbaşılar (2022) claims that also paper waste sludge can be used as an alternative bedding material for poultry without any negative effect on its welfare and behavior. Villagra (2011) studied the same material and compared it with wood shavings. There was a slight non-significant difference in production parameters and FPD, the only significant difference was in an occurrence of hocks burns which occurred with higher frequency while using paper sludge. Şahin and Çelen (2021) claim that rice hulls can be better bedding material than wood shaving because they improve a health of food pads. They conducted several experiments in farm conditions.

General principles

Important observation was done by Cengiz et al. (2011) who made a litter wet in their research and dried it consequently. They proved that a severity FPD caused by humid litter of poor quality at the beginning of the cycle can be reversed when litter is dried later during a cycle. From the perspective of FPD etiology, the ability of litter material to absorb and consequently to release a humidity it the most crucial (Bilgili, 2009). Since an affect litter on FPD occurrence was not proven by Musilova et al. (2014) they found out that a moisture content in bedding material has a significant effect on FPD occurrence.

According to De Jong et al. (2012) there are more external factors which need to be taken into account when accessing FPD. There are seasons of the year, thinning of the flock, slaughter age and breed. Mayne (2005) added that there are two main factors affecting the occurrence of FPD. Deficit of biotin can cause a higher occurrence of FPD and it is highly recommended to focus on correct dosing. The second important factor is if the bedding material is wet or not. According to Kjae et al. (2006) FPD is more frequent in female broilers and there is no correlation between FPD and BW. There are barely any lesions in slow growing birds. The relative high heritability of FPD and the low genetic correlation to BW suggests that there is a possibility for genetic selection of the birds for reduction of FPD without reducing of BW.

EFFECT OF BEDDING MATERIAL ON ANIMAL BEHAVIOR AND WELFARE

Broiler chickens are raised in different production systems. In the countries of Western Europe, there is a growing trend of extensive farming, often using slow-growing hybrids and with access to outdoor paddocks. However, in the countries outside the European Union, chickens are still raised intensively, in closed buildings, often even in cages. The reason for this difference is that consumers in the European market often care about the living conditions of animals and are willing to pay more for products from animals which live in better conditions. There are many factors which negatively affect poultry welfare. In wild chickens live in small groups where all animals know each other and where there is a strict hierarchy. On farms, chickens are kept in closed barns where there are tens of thousands of animals in one room. It causes stress. Another factor closely related to litter quality is a stocking density. Different production systems and commercial concepts allow farming of poultry at stocking density 15 – 42 kg/m^3. The lower the stocking density, the easier it is to maintain high-quality and dry bedding (O`Connell, 2022).

It is necessary to allow farmed animals to perform their natural and species-specific behavior. For broiler chicken welfare use of perches/platforms, foraging areas and dust-bathing areas are believed to be crucial. Dustbathing is natural behavior of chickens which may improve leg condition and health status through exercise

(Shields, 2004). Dustbathing improves maintaining good feather quality and removes external parasites. Frequency of dustbathing increases with the animal's age (Baxter et al., 2018).

Individual elements of animal behavior are also influenced by other factors, not just the bedding material. Chicken of fast-growing birds spend much more time sitting/lying than slow-growing birds (O`Connell, 2022). The draft in the barn reduces the activity of the chicken. If they feel cold, they huddle together and form a small group. In case of too hot conditions, they raise their wings, pant and do not move (Gussem et al. 2013).

Several trials and observations were made, where authors evaluated the preference of chicken to perform specific behavioral elements on different bedding materials. In dustbathing, we assume there is a direct correlation between frequency of this behavior and animal welfare.

Peat, straw and wood shavings

Baxter et al. (2018) claims that using a peat increases the frequency of dustbathing behavior. According to the study of Baxter et al. (2018) peat is the most preferred bedding material for dustbathing. Although peat is the most preferred, oat husks were similarly used by birds for bathing in their research. Since hulls may be more ecologically acceptable than peat, that gives them greater potential to be used. The research of Almeida Paz et al. (2010) speaks against this hypothesis. They observed locomotory disorders and proved that chicken raised on wood shavings has less health problems that these raised on rice hulls.

In addition to the positive effect on the productivity and health of footpads, chopped straw, compared with whole straw, has a significant effect on the behavior of animals because much more scratching and dustbathing behavior can be observed when chopped straw is used (Zikic et al., 2017).

Sand

According to many other researches a sand was preferred bedding material when offered. Compared with rice hulls and wood shavings birds in research done by Toghyani et al. (2010) demonstrated their preference to stay at sand when it was offered. It was also material where they performed dustbathing with the highest frequency. Sand was also a preferred material according to research of Shields et al. (2004). They also noticed that broiler chicken does not use rice hulls for dust bathing at all. Accessibility to dust bath is a good indicator of animal welfare. Preference of sand as a bedding material was proved also by Shields (2004) but in consequent research they found out that although chickens prefer sand when they are not given a choice and were placed either on sand only or only on shavings, the frequency of dustbathing has not changed and was similar. This was also confirmed by Shields et al. (2005). Ramadan et al. (2013) claims that birds reared on combination of straw and sand exhibited more standing and walking behavior than on other materials.

CONCLUSION

Whether the type of bedding material influences the performance of chickens is confirmed by some results, while others, on the contrary, did not confirm any effect.

Wood shavings and their combinations with other materials are demonstrably better bedding material than wheat straw. Their positive effect on production parameters has been proved by numerous experiments. Other materials such as peat or straw pellets also have a demonstrable positive effect on efficiency of production, the only limit is their price.

Of the various materials of wood origin, the most suitable are shaving from soft wood if they are dried properly.

Materials like sludge paper waste, leaves, or cellulose-based by-products proved their potential to be used as litter material in case there is a shortage of straw or shavings. However, the risk of contamination cannot be unmentioned. Pelletized paper has much better properties than paper itself.

Of the alternatives used outside Europe, coconut fiber proved to be the best, as it is available and has required

properties. In arid conditions, sand can be used, but excellent preparation of barn is essential in that case. Rice husks and peanut hulls are less suitable alternatives. Rice husks have lower moisture absorption capacity and chicken can mistake them for grain and eat them. Peanut husks can be source of mold and there is a risk of aspergillosis.

We think that the most important ability of the material is to accept water and to be dried. However, an important characteristic is that the material must not damage the soft footpads of the chickens. Straw can cause damage at an early age, which becomes apparent when the chickens are bigger. Materials with a finer physical structure are more suitable and preferred by chickens.

Straw pellets have a significantly positive effect on the health of footpads due to their good absorption capacity and the absence of sharp edges. We assume the same properties for a peat however this material, even it is occasionally used, has not been yet extensively researched.

It was shown that the use of chopped straw resulted in better footpad health than whole straw. We assume that the reason is that chopped straw has a larger surface, which can absorb moisture and thus allows a drier bedding to be achieved.

The correct particle size is important when wood shavings are used. Dusty bedding does reduce the incidence of lesions on footpads, but a higher mortality rate has also been proven when using softwood chopping fines.

Chickens prefer dry and loose materials for movement, sitting as well as dustbathing. Since the frequency of dustbathing is a sign of good animal welfare, peat and straw pellets may be used more in the future whereas they have exactly these characteristics. According to many observations, sand also achieved excellent results, but the problem is it cannot be used neither as fertilizer nor biogas production, and it does not have as good absorption capacity as other materials.

Even though different materials have various properties (hygiene, physical structure, pH, dustiness or water holding capacity), there are many environmental factors that can reduce the condition of litter. Some materials are easier to maintain than others, but proper management of technology and microclimate is always essential.

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