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Mini Review

Wood Based Bedding Material in Animal Production: A Minireview

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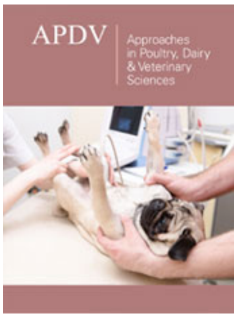

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Abstract

Bedding material is an important constituent of the animal production system. It is a key factor not only in the wellness and comfort but also for biosecurity measures applied for disease control and prevention programs. Animal production industry uses many types of bedding materials including, wood shavings, grass straws, paper, corn cobs, and rice husk, depending on the availability, price, hygroscopicity, animal comfort and environmental concerns. This review discusses the opportunities of using wood by-products like wood shavings, sawdust and chips in animal production, and their effect on health and welfare of animals and also on environment. Additionally, the microbial perspective of wood based beddings has been highlighted because generally it is considered as unhygienic material, however recent researches has shown the antimicrobial effects of this material, which can be utilized in production systems to counter the disease and lower the biological risk to health of animals, workers and environment.

Keywords: Wood shavings; Sawdust; Chips; Bedding material; Antimicrobials; Animal welfare

Introduction

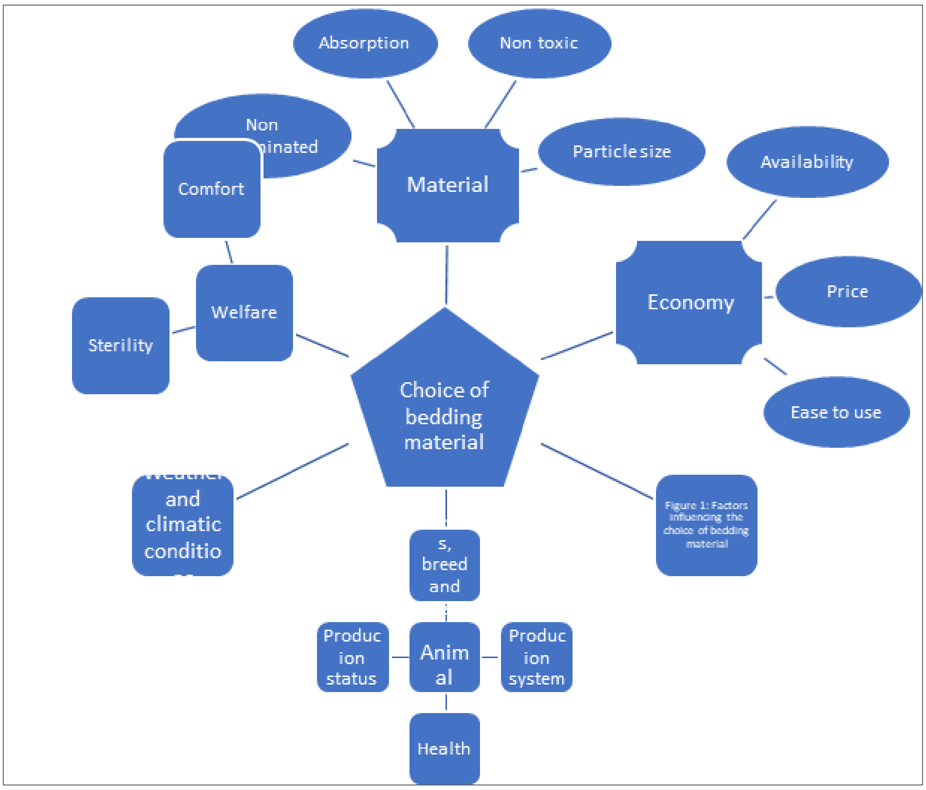

Figure 1: Factors influencing the choice of bedding material.

Bedding material is a key factor in animal production. The choice of material is generally based on comfort, cleanliness, and moisture absorbance [1]. The bedding can consist of different materials including straw, hay, corn cobs or stover, wood (sawdust, chips, and shavings), soybean residue or stubble, feathers, sand, dried compost and newspaper [2-4]. The use of aforementioned products also depends on the fittingness for the specific facility design, environment and climate, and production level and the type of animals as shown in Figure 1 (Ward et al., 2001).

Bedding material can effect on many physiological parameters of animal (Sanford et al., 2002). When the environmental temperature drops, animals need more energy to maintain their body temperature and their food consumption needs to be increased; these excessive energy requirements may even cause body weight losses [3]. In the moist environments, the retention of moisture also aligns with microbial growth which can cause health and production issues to animals (Ward et al., 2001). The scenario of the hot environment also needs some considerations regarding moisture and insulation properties [5]. Bedding also prevents bruised knees, elbows, hocks and hips, and keeps the animals clean [4,6,7]. Therefore, it is important to study different bedding systems that help animals maintain their physiological status to fight against diseases and keeping with optimal production (Sanford et al. 2002) [8].

The bedding material harbor many microbes [9], salts, nutrients [10] and other contaminants [11]; (Umar et al. 2015). The presence of pathogenic organisms poses a risk to animal and herdsman's health (OIE Animal Production Food Safety Working Group, 2006). As the udder of dairy animals comes in direct contact with bedding material, the microbial infection may cause mastitis, resulting in huge economic losses (Zehner et al. 1986). Also, the consumer's health becomes at stake because of contaminated milk harboring pathogens (OIE Animal Production Food Safety Working Group, 2006). Bedding surface is also responsible for the contamination of animal hides (Ward et al., 2001), which take these pathogens to slaughterhouses, directly posing a risk of foodborne illness [12,13]. The production of different gasses in different beddings also has a significant contribution to animal, workers and environmental health [4].

Currently, the vast variety of bedding materials are being used in the world depending on availability and economy. Therefore, the scientific community and animal welfare groups try to find the pros and cons of each system regarding environment enrichment which leads to animal welfare and performance [14]. The better environmental conditions help to improve animal health and welfare, means less sickness and lesser use of antibiotics, which is a significant contribution to tackle emerging issue of antimicrobial resistance. This review specifically focuses on the use of wood-based bedding material. We also describe the suitability, comfort, and disease control potential of wooden materials (Figure 2).

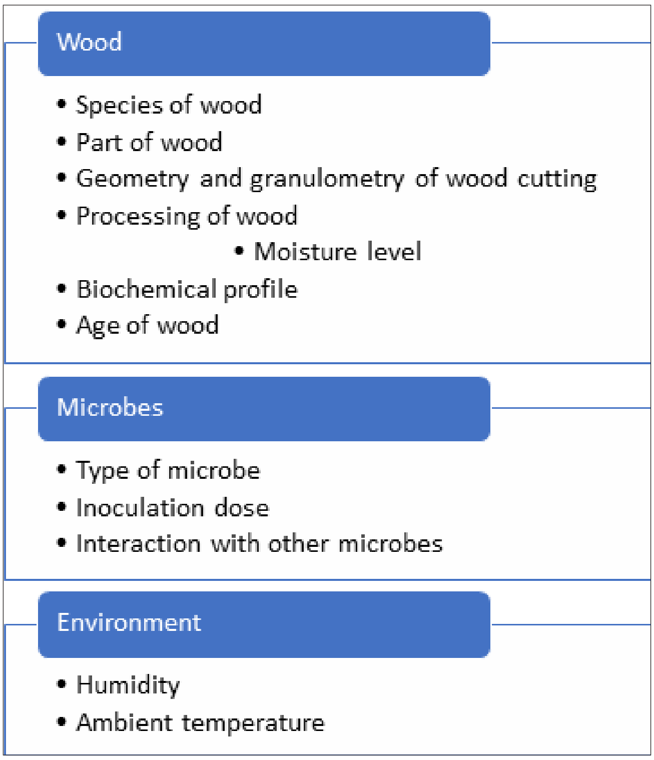

Figure 2: List of factors affecting microbial survival on wood.

Wood products for bedding

Wood is a natural material present all over the world and is used by humans maybe since the origin of mankind. Wood is sometimes directly transformed into the smaller pieces which are mainly used for energy production and sometimes for bedding material for animals. Mainly, the byproducts of wood industry, both the softwood and hardwood, are used for animal beddings [11].

The availability of these byproducts varies in different countries [15,16]. The absorption potential of these by-products depends on species, age, moisture content, and part of the wood. Also, the surface area has great influence on absorption potential of wooden products, the smaller is the particle size, the more is the surface area [11]. There are many types of wood byproducts available but generally, the chips, shavings and the sawdust are used for bedding.

Wood Chips

The chips are generally a mixture of bark, sawdust, and post peelings. They are produced when sawing lumber with coarse saws. For specific bedding transformation, wooden chips are passed through a screening process to remove bigger sized debris. Later, they are heated at about 65 °C for 20 minutes in open air furnace. This heating process not only dries wood but also eliminates many microbes [11]. A long-term project [17] of using wood chips as an alternative bedding material in cattle and sheep production, has shown that this material provides an equally high standard of welfare and cleanliness to the animals as compared to straw. Moreover, no behavioral or performance changes were seen in the studied animals.

Wood chips can be an economical solution depending on availability [15] and they need less repeated addition [18]. Otherwise, the recycled wood is also a cheaper option. Moreover, the compositing of woodchips produces a higher amount of energy making a suitable heat generation source. The manure mixed wood chips can also be sieved before compositing, and the bigger pieces can be reused as bedding. Furthermore, the compost of chips is also reusable [17] because of heat killing of some microbes [19]. The compositing of woodchip bedded manure doesn't increase the greenhouse gasses emission, in fact, it has lower release of nitrogen, lowering the ammonia burden in environment [20,21]; higher amount of inorganic nitrogen and carbon, lower amounts of phosphorus [15,22] and sulfides, and overall greenhouse gasses emissions (Spiehs et al. 2014b) making it suitable for air quality and soil amendment supporting the crop production [2,23] and lower leeching [24].

Although each wood species has different chemicals present in the bark (Laireiter et al. 2013), it is interesting to note that the woodchip bedding belonging to different species of wood has not shown any differential effect on the performance of studied animals [17]. However, the effect on environment has shown significantly different results when used 3 types of wood-based bedding materials (kiln-dried pine wood chips, dry cedar chips, and green cedar chips) and corn stover on the concentration of odorous volatile organic compounds and total Escherichia coli in bedded pack material (Spiehs et al. 2014a, 2016). Thus, we can assume that these parameters do not negatively affect the production potential of farm animals [17]; even though, the reuse of different wood species and their environmental effects may differ (Spiehs et al. 2014b, 2016).

Wood chips provide as clean and dust free environment as another popular type of beddings. For instance, [25] observed no significant difference in breathing zone endotoxin concentrations of horses bedded on straw or wood chips. However, some researchers believe the moist wood chips emit colors which may stain the coat of the show animals, making it an undesirable bedding for this purpose; and oak wood causes heat up of hooves in horses, and walnut may cause toxicity [18].

Wood Shavings

The most widely used and recommended type of wood bedding is wood shavings. Planing the kiln-dried lumber produces wood shavings. Before planing, lumber is dried in large ovens at 60 °C for the period of two weeks. The shaping of planes leaves the shavings as a byproduct [11]. If the shavings are obtained from unprocessed planning, they may have a higher amount of moisture which needs to be lowered down by drying process; this drying is carried out normally above 100 °C (Wöll and Jónsson, 2009).

Wood shavings provide a warm, clean and healthy environment to the animals housed on it [26]. This material has been proven to be a satisfactory bedding providing comfort and an ample absorbency, in fact, 4 times higher than straw. Moreover, they can be a better alternative for the animals who have allergy problems from dust present in straw; anyhow the particle size of wood shavings decreases with time but still, it is better than crop straw (Ward et al. 2001; Wöll and Jónsson, 2009). Inhalant exposure to airborne irritants commonly encountered in horse stables is implicated in the pathogenesis of inflammatory airway disease and recurrent airway obstruction, non-infectious, inflammatory pulmonary disorders that impact the health and performance of horses across all equine disciplines [27]. Wood shaving bedding accounts for the lesser amount of airborne dust concentration and allergens (Micropolyspora faeni, Aspergillus fumigatus, and mite allergen) as compared with conventional straw bedded stalls. Clements also reported higher respirable dust concentrations at the breathing zone for horses bedded on straw compared with wood shavings [28,29]. Another study supported this idea where it was observed that the airborne particulates (PM10) concentrations were found to be higher in the stalls bedded with straw compared to stalls bedded with wood shavings [30].

The ammonia emission in case of wooden shavings based bedding is lesser than the straw [31], chopped newspaper, chopped corn stalks, and recycled manure solids [21], but higher than straw pellets [30] and peat [4]. Moreover, alike wood chips, the biotransformation of wood shaving based manure produces lesser amounts of pollutants as compare to other beddings. [31] observed that the manure mixed with wood shaving based bedding generated lesser amounts of carbon dioxide, methane, nitrous oxide, and higher amounts of oxygen as compared with wheat straw and rye straw beddings.

As it is a known fact that the feces of animals mix with the bedding material and may allow growth of fecal microbes, and also stick to the skin of animals, the study by (Ward et al. 2001) showed that the horses housed at wooden shaving had the higher number of coliform bacteria on skin as compare to those which were reared on wheat straw or newspaper bedding. They believed these higher levels are due to finer particle sizes present in wood shavings. However, the enteric microbial colonies in the nasal cavity were lowest in horses kept on wood bedding. The study performed on dairy calves showed that fecal coliform was highest on wheat straw and rice hulls not on wood shavings. Moreover, the calves raised on wood shavings were lesser dirty as compared to those on granite and sand [26]. The behavioural changes can be a marker of animal wellfare standards [32]. Although, (Werhahn et al., 2010) reported mare differences in horses behaviour (standing, eating, lying, occupation with bedding material) when they were bedded on wood shavings and straw; overall, the wood shavings do not have a negative effect on growth and performance of animals when compared with other bedding sources. Likewise, a study on dairy calves reported no significant differences in serum parameters of cortisol, immunoglobulin G concentrations, alpha(1)-acid glycoprotein, and the neutrophil: lymphocyte ratio irrespective of bedding [26].

Sawdust

The smaller particles generally having the size of 2mm are produced as a byproduct of wood sawing and cutting. This size of wood has higher surface area meaning more moisture absorption. Although with the advent of modern technologies, the wood sawdust is being utilized for the production of other products such as pellets for burning as an energy source, sawdust still has the potential to be used as bedding material for animals. It is recommended that the sawdust be kiln- dried to gain the advantages of cleanliness and absorbability. Cleaning is fairly easy with this highly absorbent material because soiled spots tend to clump making the disposal easier [18].

Studies have shown that pigs reared in deep litter system consisting of sawdust show better performance and meat quality making it an economical solution and welfare perspective [13]. Moreover, sawdust is used as bedding in pig farms and transport vehicles, and it doesn't seem to enhance aggressive behavior or decrease welfare of animals [33,34]. The studies has also shown that dairy calves show more growth and comfort level on sawdust bedding as compare to concrete [35], rubber, sand and stones (Worth et al. 2015).

The sawdust may stick to hair and wool of some animals, especially arising the issue of wool quality in sheep production, still, it is a better alternative to sand and granite bedding regarding the cleanliness of animals [26]. It is assumed that the contaminated sawdust may also stick to udder causing mastitis in dairy animals but the automatic milking system almost completely cleans the bedding material from teats [36]. Moreover, the finer particle size which may cause inhalation problems, resulting in snotty noses, wheezing and coughing. Excessive coughing ultimately can lead to rectal prolapsing and/or other health issues that are detrimental to the performance of animals [37]. Accordingly, animals perform better on larger particle size for bedding [38,39].

One should be careful about the safety of the sawdust coming from a wood waste industry which may contain persistent organic pollutants [40]. However, some recycling processes maintain the safety of bedding material without harmful effects on animals [41]. Sawdust may be contaminated by some microbes which can cause infection not only in animals but their zoonotic potential can reach up to humans too [39] (Sampimon et al. 2006; Komatsu et al. 2017). It doesn't mean that wood bedding is less safe in such scenario [42] because similar organisms have been isolated from other beddings too [43]. This risk can be reduced by using fresh or recycled instead of contaminated and used sawdust [39,41] (Verbist et al. 2011).

The smaller size of sawdust as compare to wood shavings and chips, make it to break down faster [18]. Sawdust bedding loaded with cattle dung can be used for compositing (Won et al. 2017). The pig bedding including sawdust and feces can be composted in a period of two months (Tiquia et al. 1996); and if forced aerated composting is used, it doesn't require the addition of bulking agent unlike turned piles (Tiquia and Tam, 1998).

The sawdust bedding doesn't seem to be very suitable to be used in stables. Ninomiya et al. [44] reported that lateral lying was observed less frequently when sawdust was used as bedding concluding that use of this bedding material will decrease the welfare of stabled horses, similar observations were reported by Kwiatkowska-Stenzel et al. [45]. Janžekovič et al. [46] reported that when the horses were bedded on different materials, the sawdust stalls had the highest amount of exclusion of daily quantity of bedding material, more amount of sawdust stayed in the stalls, and about double amount of fresh sawdust was added as a replacement as compared to other bedding materials. Moreover, it required up to 50% more time to put the sawdust bedding material, prepare it and clean the stalls.

Microbiological perspective of wood-based bedding

Wood has antimicrobial properties due to chemicals present in it in form of extractives and its complex physical structure and hygroscopic nature, which doesn't allow many types of microbes to propagate freely. This chemical and physical antimicrobial potential of wood against microbial flora is dependent on multiple factors [47]. It is a well-established fact that the extractives present in wood have antimicrobial properties and these chemicals have been isolated to use them, against different microbes, either in form of medicines or antiseptics [48]. On the other side of the coin, there are some chemicals present in wood which has the coloring potential and if such material is used as bedding for show animals, they can color their hides posing a negative effect. Some of these chemicals may prove to be allergic and toxic to animals [18]. The physical structure of wood doesn't allow microbes to move freely. In fact, they are stuck in the porous structure of wood [49]. The wood surface contamination experiments show that microbes are absorbed deep inside the wood pores reaching the depth of 3 mm, and it is difficult to isolate them by touch or swab method [50]. The lower or no bacterial recovery from wood surfaces depicts that they have lesser potential to cause contamination to objects which come in contact with the wood surface [51]. Also, the wood absorbs the moisture leaving microbes dry out to death [52]. On the other hand, some bacteria and fungi live on wood, and they use wood structure to survive on it. For sawdust and wood shavings there are additions available which contain enzymes and bacteria that feed on ammonia: thus, the wet spots do not have to be removed but can stay where they are, because the bacteria bind the potentially harmful ammonia (Wöll and Jónsson, 2009). Some microbes also use wood structure to form biofilms which may nourish pathogenic microbes too. However, corn stover is a more easily usable energy source for microorganisms compared to sawdust (Kirchmann, 1997).

The different structural modification changes the interaction of wood with microbes, therefore, the same microbe may have different survival rates on wood chips, shavings or sawdust [39]. Matlova et al. [39] observed that wood shaving bedding was pathogen-free as compare with sawdust being used for pigs. This variation might be correlated with the presence of moisture, surface area, surface cutting, species of wood, quality, grade and process of production (Breen et al. 2009) [12]. For instance, we can explain the interaction of wood with Staphylococcus aureus which is one of the leading causes of mastitis in dairy animals. It survives in the environment and the infection remains subclinical or chronic, leading to economic losses. In some recent studies, it has been observed that this bacterium doesn't survive on many wood species, because of antimicrobial properties of wood [53]. Even the multiresistant strains which are of modern economic health concern, do not propagate on a certain type of wood [54].

The low pH of wood may also be considered as an additional antimicrobial factor; for example the oak has very acidic pH and shows a strong antimicrobial activity against many microbes [54]. Godden et al. [55] studied the microbial survival on organic and inorganic bedding materials from 49 dairy farms. The wood shavings showed the lowest pH of 4.3 and other bedding materials had basic pH of 8.2, 8.3 and 8.9 for clean sand, used sand and digested manure solids respectively. The wood shavings and clean sand were the best bedding materials showing lower growth in number of Enterococcus faecium and Klebsiella pneumonia. Finally, the microbial safety of wooden material as bedding depends on quality and grade of material and it is important when implementing disease control programs in animal production (OIE Animal Production Food Safety Working Group, 2006; [1]). (Zehner et al., 1986) described the growth of environmental mastitis pathogens in various bedding materials and found that the mastitis-causing organisms (Escherichia coli, Klebsiella pneumonia, and Streptococcus uberis) had lesser survival rate on wood chips and sawdust. Godden et al. [55] reported the decrease in the number of Enterococcus spp. on wood shavings as compare to other bedding materials. Although, other environmental factors may also have affected the survival of microbes, the antimicrobial potential of wood also has a strong argument. The potential of wood-based bedding material against antimicrobial resistant microbes makes it a desirable material to control this important issue which is of concern in both humans and animals. Antimicrobial resistance threat is also linked to the higher amount of antibiotics being used in veterinary practice, better use of biosecurity protocols can help to mitigate it [56]; for example, a lesser amount of antibiotics were needed in the calves housed on wood shavings [26]. Moreover, zoonotic pathogens may also not survive on wooden beddings, solving an important public healthcare issue. As an example, no isolates of Mycobacterium avium subsp. Hominissuis, which has zoonotic potential, were isolated in the pigs raised on sawdust bedding as compare to the herd which was raised on peat [42]. Contrarily, the prevalence and survival of E. coli O157:H7 was more on sawdust bedded dairy farms than sand bedded farms [12]. Other studies have shown that the coliforms and Klebsiella spp. to be more numerous when cows were bedded on sawdust but Enterococcus and Streptococcus spp. to be more abundant when cows were bedded on sand (Zdanowicz et al. 2004) [55]. However, the clay-based acidic bedding and alkaline conditioner reduced environmental pathogens like Staphylococcus aureus, Klebsiella spp., Streptococcus uberis and coliform bacteria on sawdust bedding, teat skin and teat canal without affecting teat end integrity [57,58].

Conclusion

The use of wood-based bedding material can be encouraged owing to its antimicrobial properties depending upon availability and cost in different parts of the world. It provides comfort to animals and doesn't have a negative influence on the production of animals. The structure of wood and chemical profile stops the growth of some harmful pathogens, thus the method of production and wood species [59-61] has a clear effect on the antimicrobial behavior. After use, this bedding material can either be recycled or biotransformed to be used for other purposes. Moreover, wood represents ecological ideas that are important for sustainable animal production. Finally, the choice of wood material as bedding should be kept in mind while implementing disease control and animal welfare programs. There is lack of data specifically correlating the effect of species, particle size, and production methods of wood based bedding on the animal health and welfare, and microbial interaction. In light of these findings, it will become comprehendible that which wood species and what type or processing method or treatment of wood bedding would be feasible and economical to be used in specific animal production system.

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