Plant Archives Vol. 25, No. 1, 2025 pp. 1947-1954 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.283

OPTIMIZING LIVESTOCK WELFARE AND PRODUCTIVITY: A COMPREHENSIVE REVIEW OF BEDDING MATERIAL IMPACTS

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(Date of Receiving : 03-01-2025; Date of Acceptance : 16-04-2025)

ABSTRACT

Optimizing farm management practices, particularly in animal housing, is paramount for maximizing livestock profitability and ensuring animal well-being. Bedding materials serve a critical function, influencing animal behavior, health, and productive outputs by providing comfort and protection. This comprehensive analysis evaluates the advantages and limitations of diverse bedding options, including sand, gypsum, sawdust, wood shavings, straw, and recycled paper, across dairy, small ruminant, and poultry sectors. We scrutinize the effects of these materials on key performance indicators, such as disease prevalence (mastitis, lameness, pododermatitis), behavioral patterns (resting duration, foraging activity), reproductive success, and overall production efficiency. The review emphasizes the pivotal role of bedding characteristics, including moisture absorption capacity, microbial burden, pH balance, and physical structure, in directly and indirectly shaping animal health and farm sustainability. By systematically comparing the attributes of each material, this study aims to provide evidence-based insights for selecting and managing bedding to improve livestock health, welfare, and production outcomes.
***Keywords*:** Farm management practices, livestock profitability, bedding materials

Introduction

Effective farm management is crucial for enhancing profitability (Kumari *et al*., 2020; Singh *et al*., 2020c) and necessitates attention to housing conditions. Providing shelter from environmental extremes like intense sunlight, rain, and cold significantly influences animal behavior, including resting, feeding, and rumination, as well as overall production and reproductive success. Utilizing bedding materials as flooring is essential, and assessing floor moisture levels and drying times is vital for animal welfare. Proper floor design and management are key to improving animal health, longevity, comfort, and productivity. Maintaining a balance between animal comfort, hygiene, and feed efficiency is paramount. Bedding provides a comfortable resting area, promoting udder health and influencing milk quantity and quality (Singh *et al*., 2020). Common bedding materials in free-stall barns include sand, sawdust, wheat straw, and wood shavings (Ferraz *et al*., 2020). Improved bedding and flooring contribute to a comfortable resting environment, enhancing animal health and productivity (Maurice Tuyttens, 2005). Bedding reduces skin pressure, heat loss, and contamination from animal waste (Koren, 2017). However, organic bedding can harbor pathogens such as viruses, bacteria, parasites, and fungi (Skora *et al*., 2016).

An ideal bedding material should be light to medium in bulk, exhibit strong absorption, dry rapidly, be soft and compressible, have low thermal conductivity, absorb minimal air moisture, be cost-effective, and be suitable for fertilizer use (Sami, 2000; Lacy, 2002; Abd El-Maty, 2005). Bedding quality is determined by moisture, pH, ammonium nitrate content, caking, and water-holding capacity (Gençoglan *et al*., 2017). Straw's low water-holding capacity is attributed to high lignin content and its hydrophobic properties (Boulos *et al*., 2000).

Microbial pathogens pose a significant concern in the food industry (Saraiva *et al*., 2022), with litter

quality impacting food safety (Munir *et al*., 2019). Bedding influences indoor air quality and manure management (Maurice Tuyttens, 2005). Ammonia gas, dust, and biological aerosols degrade air quality, increasing respiratory disease risks. Ammonia concentration is affected by bedding quality and quantity, as well as manure management (Raymond *et al*., 1994; Louhelainen, 1997). The amount of bedding used determines animal comfort, with typical ranges varying: 4-8 kg of straw or chaff, 6-10 kg of sawdust or sand, and 4-5 kg of other materials.

Table 1: Comparative Analysis of Different Bedding Materials:

Material	Potential	Constraints	References
Sand	Accessible, highly absorbent and adsorbent, and clean bedding that doesn't cake	Repercussions of sand mining for the environment. Absorbency is low in desert sand.	Shields *et al*., 2005, Garces *et al*., 2013
Gypsum	Readily available, cheap, and absorbent, reduces bacterial load, NH_3, and phosphorus emission.	No beneficial effect on growth	Watts *et al*., 2017, Sheng *et al*., 2015, Burt *et al*., 2017
Sawdust	Absorbent and improves welfare through dustbathing and foraging	Low ability to release moisture and frequency caking. Fine particles may predispose to respiratory problems, risks of chemical preservatives.	Musa *et al*., 2012, Mijinyawa *et al*., 2006
Wood shavings	Conventional, high absorbent and adsorbent material, improve welfare through dustbathing and foraging	Expensive due to competition in various industries, potential risks of contamination from chemically treated woods.	Embury 2022, Charles 2005
Straw	Readily available, cheap, chopping improves WHC and provides for foraging	Low WHC due to lignin content.	Teixeira *et al*., 2015, Grimes *et al*., 2002
Newspaper	Easily available and cheap	Low absorbency, easily cakes and causes breast blisters.	Teixeira *et al*., 2015, Musa *et al*., 2012.

Impact of bedding material on the Livestock sector:

Bedding materials directly influence production, health, product quality (Sheffield *et al*., 2018), and animal welfare (Garcia *et al*., 2012). Stress from poor bedding can reduce feed intake, affecting body condition and hormone secretion, which impacts growth, puberty, birth weight, mammary (udder) development, and milk production (Bova *et al*., 2014). Sand bedding provides traction and facilitates natural behaviors (Bell, 2007), improves resting and feeding behaviors (Sinha *et al*., 2017), reduces hock injuries (Weary and Taszkun, 2000), offers hygienic conditions (Britten, 1994), and eases movement.

Impact of bedding materials on the Dairy Sector (Large ruminants)

Effect of Bedding Materials on Health and Performance of Dairy Animals

Due to the high amounts of bacteria that may be present in the bedding material, milking cows kept in poorly maintained and confining housing may develop environmental mastitis (Faull *et al*., 1996). Bulk milk somatic cells and environmental bacteria are typically found in larger concentrations in organic bedding materials than in inorganic ones (Godden *et al*., 2002; Rowbotham & Ruegg, 2016). For the dairy business, mastitis is regarded as one of the most destructive issues (Bhakat *et al*., 2017; Kumari *et al*., 2019; Kansal *et al*., 2020). Concrete floors have greater rates of uterine infection cases, fever, mastitis, and teat and udder wounds than sand bedding (Kumar *et al*., 2017). Sand has the fewest incidences of mastitis disease or udder injury, followed by concrete floor bedding and rubber mats (Madke, 2007).

Sand-bedded animals have the greatest ammonia concentrations, while composted bedding materials produce the most methane when compared to bedding materials like straw, free stall, and wood chips (Leso *et al*., 2020). While increased methane emission in composted bedding may be caused by the presence of more decomposed organic components, excessive

ammonia emission in sand bedding may be caused by the absorption of more urine and feces.

Effect of Bedding Materials on Lameness and Hock Lesion of Dairy Animals

Wet circumstances can lead to weaker hooves and increased risks of foot injury and long-term disability, while bedding material type is a significant source of exposure to udder infections (Schutz *et al*., 2015; Tucker and Weary, 2004). One of the main risk factors for lameness is prolonged standing on concrete (Singh *et al*., 1993). High friction and abrasive hard bedding surfaces may lead to hook lesions (Brenninkmeyer *et al*., 2012). Dermatitis, heel horn erosion, white line hemorrhage, sole ulcer, and white line separation are less observed on the hoof health of tied dairy cows on a rubber-slatted floor as compared to a hard floor (Hultgren & Bergsten, 2001).

Other health issues include skin lesions, changes to the teat, joint issues, elevated somatic cell count (SCC) (Regula *et al*., 2004; Fulwider *et al*., 2007), hemorrhages, swelling, and scabs have been linked to hook lesions (Livesey *et al*., 2002). Dairy animals may become uncomfortable as a result, which would negatively impact their performance as a whole. Lameness in dairy cows may result in premature culling, a longer time between calvings, labor and treatment costs, changes in milk supply and fat, and unproductive future income (Peake *et al*., 2011). High-producing cows are more likely than low-producing ones to develop hook lesions, particularly as lactation progresses and the number of lactations increases (≥270 days) (Potterton *et al*., 2011; Kielland *et al*., 2009).

Effect of bedding on the behavior and welfare of dairy animals

Compared to the peanut–rice combination (212 min/d) and peanut shell (196 min/d), cows slept on rice husks for a longer period (337 min/d) (Li *et al*., 2021). According to Manninen *et al*. (2002), the quantity of laying bouts can be regarded as a significant indicator of the caliber of the bedding materials offered. Dairy cows that are compelled to use hard surfaces, particularly concrete, have shorter lying times and longer standing times (Haley *et al*., 2001). According to Reich *et al*. (2010), dairy cows have been seen to lie down more frequently in the winter than in the summer and to choose dry bedding over wet bedding.

Dairy cows' health and welfare depend on getting enough sleep (Tucker *et al*., 2021). Growth hormone and milk production are decreased when cows are not given enough time to rest (Munksgaard *et al*., 1996). The volume, kind, and wetness of bedding all have an impact on the quality of rest, which is another essential aspect in deciding how adequate the rest is (Schutz *et al*., 2019). According to Fisher *et al*. (2003), calves lying on woodchip surfaces spend no more than 45% less time than those lying on muddy or concrete surfaces. According to Van *et al*. (2011), cows would rather lie down on bedding surfaces that are cozy, soft, and dry for longer periods. Because of its soft, impermeable texture, rubber mats allow for easier cleaning and lower microbial loads while also improving the welfare of dairy cows by reducing leg and udder issues (Lendelova *et al*., 2019; Allen *et al*., 2013).

Effect of bedding material on reproductive performance of dairy animals

When recurrent breeding instances are correlated with bedding material, concrete floors had the highest number of cases, followed by sand and rubberized bedding materials. According to Kara *et al.* (2015), instances of dystocia and retained placenta were less common in sand bedding and more common on concrete and rubberized floors. According to Gnyp and Utvinczuk (1993), cows kept in litter housing had a greater fertility rate than cows kept in other without litter housing. Slick floors significantly reduced mounting activity for oestrus detection compared to rough floors; yet, for appropriate mounting activity, a softer surface, such as pasture-based, is recommended over hard bedding, such as concrete (Palmer *et al*., 2010).

Effect of bedding material on Productivity of dairy animals

According to Stone *et al*. (2017) and Munksgaard *et al*. (2020), there is a positive correlation between cows' milk yield and their lying time; the longer the lying time, the higher the milk yield. According to Graunke *et al*. (2011), Holstein cows placed on soft rubber mats gained 9.09% more weight each day than cows raised on concrete floors. According to Zhang *et al*. (2020), cows raised on bedding made of recycled dung produced a much higher average daily milk yield than those maintained on hardened floors. Transferring cows from concrete floor barns to barns with deep recycled manure bedding resulted in an average 13.3% increase in milk yield per cow in the barn (Marcondes *et al*., 2020).

Impact of bedding materials on small ruminants:

Due to a lack of grazing land and low pasture quality, livestock businesses are showing a strong interest in the intensive system of raising small

ruminants. Due to the many benefits that come with it, housing for small ruminants on elevated slatted floors is growing in popularity.

Effect of bedding on growth of small ruminants

Growth performance, body condition score, biometry, and cleanliness were all better for lambs raised on elevated plastic slatted floors, and during the growing period, lambs bedded with straw had significantly higher ($P < 0.05$) ADG and DMI than lambs bedded with sand (Jaborek *et al*., 2016). Vasseur *et al*. (2006) found that lambs on expanded metal felt more uncomfortable on a harder flooring surface, which led to lower DMI and ADG than lambs on softer flooring surfaces bedded with sand or straw.

Effect of bedding on behavior of small ruminants

The provision of straw bedding reduces the aggressive and stereotypical behavior of fattening lambs compared to those without straw areas (Pascual-Alonso *et al*., 2015). Kashyap *et al*. (2024) found that the frequency of standing, lying, feeding, grooming, and fighting among goat kids is better when bedding material is used instead of concrete flooring to ensure better animal welfare and production. After feeding, sheep kept in Norway first preferred to lie down on straw or wood rather than expanded metal and straw on the wooden floor (Faerevik *et al*., 2005). Likewise, a study on goats indicated that goats spent less time resting when the resting area was limited as opposed to the medium and big area; lying time also rose in the activity area due to a decrease in lying space (Ali *et al*., 2016; Andersen and Bøe, 2007). Because of their absorption qualities, goats prefer to urinate on soft surfaces like sand and wood shavings rather than hard ones to prevent splashback onto their bodies (Sutherland *et al*., 2017). Because sheep do not have designated dunging sites and are expected to urinate and defecate in all sections of the pen, bedding type and quality may also affect ovine behavior, including walking and lying (Teixeira *et al*., 2013).

Impact of bedding material on the Poultry sector:

Poor litter quality is one of the primary welfare issues in contemporary broiler production, which is characterized by its great intensity (Ferrante *et al*., 2006). Because broiler chickens come into intimate touch with litter, bedding material has a big impact on their life, health, and productivity. In many places, sawdust and wood shavings are the most often used litter materials in commercial broiler production.

Effect of bedding on health of broiler

A bird's skin condition is directly impacted by the quality of its litter material; moist litter poses a significant danger for contact dermatitis, which includes blisters on the breast, hock burns, and foot pad dermatitis. The type of bedding has a major impact on the broiler's growth performance and carcass quality (Billgilli *et al*., 1999b). According to El-Deek *et al*. (2011), broilers raised on recycled newspaper litter had the lowest BWG, whereas those raised on recycled shaving wood + newspaper and barley straw + newspaper litter had the greatest BWG.

Effect of bedding on footpad health

Footpad dermatitis (FPD), or necrotic lesions on the plantar surface of the footpads, is influenced by the bedding materials. Broilers experience pain and agony when FPD lesions develop into deep ulcers. According to Gussem *et al*. (2013), the pain may cause the chickens to move less and eat less, which would lower their performance. Nearly 25% of heavy strains of broiler chickens have chronic pain for at least one-third of their life due to bone and joint disorders (Webster, 2008). Abraham *et al*. (2021) observed that while litter wetness has a significant impact on the severity of FPD, orange maize, which is rich in carotenoids and antioxidants, also lowers FPD and improves the weight gain of broiler chickens. According to Zikic *et al*. (2017), broilers raised on chopped straw had a reduced incidence of FPD than those raised on full long straw.

Effect of bedding material on behavior of poultry

Broiler chickens exhibit specific behaviors while they are on bedding substrate. Sand is one of the easier and less expensive possible substrates (Shields *et al*., 2005) that could be used to promote normal behaviors in broilers, such as walking, foraging, and dust bathing, that call for energetic movement and leg exercise, thereby reducing leg issues. Perches/platforms, foraging areas, and dust-bathing places are thought to be essential for the welfare of broiler chickens. Chicken's natural habit of dustbathing may help them exercise and maintain better leg health (Shields, 2004). For dustbathing, broilers favor sand over wood shavings, paper bedding, or rice hulls, according to research by Shields *et al*. (2004) and Toghyani *et al*. (2010).

Conclusion

The strategic selection and management of bedding materials stand as critical determinants of livestock health, welfare, and production efficiency across diverse sectors. This analysis underscores the necessity of evaluating material-specific attributes,

such as absorption capacity, microbial load, and structural integrity, to optimize animal comfort and performance. Sand, while offering traction and reducing certain health issues in dairy animals, necessitates careful consideration of its environmental footprint. In small ruminants, straw and elevated slatted flooring enhance growth and mitigate undesirable behaviors, while in poultry, sand and wood shavings promote natural behaviors and minimize footpad dermatitis. This review also illuminates the complex interactions between bedding type and environmental factors, including indoor air quality and waste management, which can indirectly affect animal health. Future research should prioritize the development of sustainable bedding alternatives that harmonize animal welfare with ecological responsibility. Furthermore, establishing standardized protocols for evaluating bedding quality and its impact on livestock performance is essential for facilitating informed decision-making in farm management. Ultimately, the implementation of tailored bedding strategies is crucial for enhancing livestock productivity, safeguarding animal well-being, and fostering sustainable livestock farming practices.

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