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A review: Floor/bedding material, key factor addressing welfare and performance of dairy animals

Ashutosh Dubey

Scientist, AICRP on Mechanization of Animal Husbandry, SVCAET&RS, IGKV, Raipur, Chhattisgarh, India

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Corresponding Author: Ashutosh Dubey

Abstract

Welfare and health of dairy animals is very important for long-term productivity and longevity. Milk and milk products demands from dairy sector are increasing dramatically. For intensifying the level of production, animal production systems are becoming highly mechanized. The systems in which the animals are reared along with their resting surface have direct influences on productive and reproductive performances of the dairy herd. As per the ease in availability, stage of animal, ease to use, availability of labour and cost economic analysis, livestock owners prefers different kinds of floor/bedding materials. Each floor/bedding material has it's own peculiar characteristics, which determines the index of comfort for dairy animals. However, the ideal features would include inert nature, cleanliness, adequate particle size, minimum moisture content with maximum comfort to the animals. On the basis of chemical nature, these bedding materials may be categorized in to organic and inorganic materials. In general, the high carbon and nitrogen content of organic materials promotes the growth of microorganisms and high ammonia emissions. Each bedding material owes its own advantages and disadvantages like comfortability, milk yield, disease incidences, oestrous detection and various other reproduction parameters. Thus, the choice of bedding material may be guided depending on the benefit cost analysis of various parameters.

Keywords: Welfare, floor, bedding material, productivity and longevity

1. Introduction

With the increase in world's global population that may reaches up to 9 billion by 2050 (FAO Commission on Genetic Resources for Food and Agriculture, 2007) [24], the demand for livestock products as a food will also be increased (Tona, 2018) [61]. Thus, it will exert a tremendous pressure on the dairy sector to fulfil this demand (Britt *et al*., 2018) [6]. To, compete with this situation, the improvement in livestock management systems is of utmost importance. It is a common saying that "there are four pillars of livestock management i.e. breeding, feeding, housing, health/disease management. The improvement in production cannot be expected if the management in any of these four pillars is inadequate (Kumari *et al*., 2020; Choudhary *et al*., 2025) [39, 15]. For long term profitability and longevity, the animal production systems are becoming highly mechanized but due consideration should also be given for health performance and welfare issues of an animal, which can be improved by providing adequate comfort through housing management of dairy animals. Thus, this topic deals with the housing management in general and bedding/flooring management in particular, it's types, their peculiar characteristics and effect on productive, reproductive, profitability and longevity of dairy animals.

The bedding material used should have certain ideal characteristic *viz*. inertness (should not readily reacts with the animal's body/housing equipments and environment), comfort (with minimum stress), have adequate moisture content (neither too high to favour microbial growth nor too low to spread with air), clean and facilitates easy cleaning and should have adequate particle size (with lesser chances for microbial contamination) (Choudhary *et al*., 2025) [15]. However, the choice of bedding materials by livestock owners depends upon economics, availability, type of climate, stage of animal, renewing frequency and waste management systems.

The different types of materials can be used for the purpose of bedding which may be organic (straw, hay, wooden shavings, crop residues, news papers, wood chips, saw dust and composed manures) or inorganic (sand, limestone, gypsum, etc.). Similarly, dairy farmers prefer different floor types *viz*. stones, bricks, concrete, rubber mats/mattress according to their own status (Ferraz *et al*., 2020) [25].

Peculiar characteristics of different bedding/flooring materials

1. **Sawdust:** It is a waste product obtained from timber and wood industry, which is having moisture of 10.8% with water retention capacity of 50%. Since, it is absorbent in nature, thus, it's moisture content increases rapidly with absorption rate (24 hrs.) of 270.2% & moisture evaporation rate (12 hrs.) of 70.5%. Due to it's high nitrogen content, it's ammonia emission rate is 1.70 mg/m^2/h. As it is organic in nature with small particle size, it promotes bacterial growth and is found to be associated with more *Klebsiella* mastitis (Buli *et al*., 2010) [7].
2. **Wooden Shavings:** They are by-products from wood

and timber industry with optimum moisture content of 11.7%. It has high moisture absorption rate (24 hrs.) of 540.2% along with high evaporation rate (12 hrs.) of 75.4%. The emission of ammonia occurs @ 13.52 mg/m^2 with emission rate- 1.63 mg/m^2/h. The wooden shavings do not tend to cling to teat skin and support slower growth of bacteria. However, some woods, like cherry, can be toxic to the animals (Ahn *et al*., 2016) [1]. Moreover, it poses various health issues, on using shaves of woods that are chemically treated (Choudhary *et al*., 2025; Embury, 2022) [15, 20].

3. **Crop residues like Rice husk:** They are the by-products of agricultural industry. Thus, easily available and relatively cheaper. It is having moisture of 8.7% with absorption rate (24 hrs.) of 179.4% and evaporation rate (12 hrs.) of 57.8%. They ammonia emission is very high @ 64.51 mg/m^2 with emission rate- 3.15 mg/m^2/h. The major drawback with this bedding material is that on exposure with water/urine and excreta of animal, it becomes too bulky for manure systems. They are more often associated with increased levels of mastitis from *Streptococcus uberis* infections (Ahn *et al*., 2016) [1]. However, it was found to provide more warmth to the animals during winter season as compared to rubber mat and composed material used fir bedding (Dimov *et al*., 2017; Chopra *et al*., 2021) [19, 14].
4. **Compost/Dried manure solids:** They are renewable source of bedding material with high content of moisture (average of 64-73%) in the unused dried manure solids bedding. The level of fine particles (≤ less than 2 mm size) ranged from 31 to 74%. It is useful in dry environment, as, on moisture, it acts as an excellent medium for bacterial growth, thus posing greater chances for udder infections (Wallace, 2007) [69].
5. **Recycled manure solids:** These are the by-products of methane digesters/biogas slurry. It is having high moisture level (About 70%), thus acts as an excellent medium for bacterial growth. However, such type of bedding material is mostly used in temperate regions, where it provides adequate heat to the animals (Wallace, 2007) [69].
6. **Sand:** It is economical and easy available material. Being inert in nature and due to its inorganic nature, it does not support the growth of microorganisms. As long as the sand is kept dry (from urine, milk leakage or the elements on open sided barns) it will remain non-compactable. However, it is non-absorbent with quick evaporation time, hence, even on getting wet, the moisture gets reduces quickly. Since, it provides insulation to the animals, thus, reducing the heat stress (Sahu *et al*., 2018) [52]. The loose texture and non-cohesive particles are seemingly lubricant under pressure; this eases the impact on the cow's hard contact points and reduces hock lesions and hair loss (Stowell & Inglis, 2000) [59]. Preference tests have also been used to show that cows actively prefer sand to other bedding types (Tucker *et al*., 2003) [63]. However, the manure handling is the biggest challenge in sand bedded barns. Flush barns with sand require at least 2 to 2.5% slope to keep heavy sand moving in the flush liquid. Generally, a trench is incorporated at bottom of the holding area to separate the sand from manure.
7. **Limestone:** It is a natural, inert material which allows porosity for liquids to drain evenly. It is relatively costlier and due to its chemical nature, it has potential to dry-out and damage teat and udder skin. However, it effectively controls the level of microbial contamination. The limestone (crushed) having 10 mesh screening size is the optimum base material for livestock stall and is often used sparingly with other bedding materials. (Anonymous, 2019) [3].
8. **Cow stall mats:** They are generally constructed of a 1.9 to 2.5 centimetre thick and is made up of thick industrial grade solid rubber or a multi-layered vinyl. It is impervious to water, bacteria and mould and being solid provides comfort like concrete floor, however, offers a non-abrasive, non-skid surface that adds traction for cows. At the time of winter, it acts as an insulating layer between the animal's body and cold concrete base of stall (Kour, 2017) [37].
9. **Geotextile/Rubber Cow mattress:** They have waterproof exteriors made of either synthetic materials or rubber, inner core filled with a variety of materials including rubber crumbs, polyethylene foam, gel and water. The incidences causing abrasion of hock joint is meagre with these mattresses. Commonly, it is installed in rows, attached to one another, and is available in various sizes to fulfil the requirement of typical stall sizes (Endres, 2012) [21].
10. **Concrete:** The concrete flooring is relatively expensive and provides harder surfaces to the animal. It is having low moisture (<2%) content and absorption with high rate of evaporation. The compressive strength of concrete floor is high and such floor becomes slippery on wetting, however, the manure management is easier in such floor (Telezhenko *et al*., 2009) [60].

Cow comfort and performance of dairy cows

The comfort level of cow can either be assessed by its lying behaviour (Stone *et al*., 2017 and Munksgaard *et al*. 2020) [58, 43]. Out of a day, dairy cow prefers lying/resting as compared to other behaviours i.e. about 12-14 hours (50% of total daily time budget) is essential for adequate health and performances (Gupta *et al*., 2016). Moreover, the systems of feeding employed by the owner, also alters the duration of lying *viz*. 8 hours/day in pasture feeding (Sepulveda-Varas *et al*., 2014) [55], while 12.5 hours/day in case of stall feeding (Charlton *et al*., 2014) [12]. Similarly, the adequate lying duration for a lactating cow is about 11 hours/day in case of free stall systems (Von Keyserlingk *et al*., 2012) [68], however, a lying duration of 10.9 hours to 11.5 hours/day was suggested by Philips and Rind (2001), for different types of housing systems. The lying behaviour varies with certain management factors *viz*. Social ranking, system of housing, design and material of lying area, stocking density, time, duration and period of milking. The season also markedly affects the duration of milking as the lying duration is higher in winter season as compared to summer (Steensels *et al*., 2012) [57]. It is well known fact that for making 1 volume of milk, about 500 volume of blood is required, thus the increased duration of laying, increases the supply of blood to the udder (Metcalf *et al*., 1992) [42], up to 24-28% as compared to standing i.e. 4.56

l/min. vs 3.56 l/min. (Cook and Nordlund, 2009; Rulquin and Caudal, 1992) [16, 50]. Less laying/comfort and more standing poses stress to dairy animals, which increases the level of plasma cortisol (Takeshi *et al*., 2017) along with reducing the level of growth hormones and Insulin like growth factors. The indirect effect of stress is reduced feed intake, which lowers desired body condition score, and reduced secretion of leptin (Bova *et al*., 2014; Kashyap *et al*., 2024) [5, 36], thus, affecting the growth of calves, onset of puberty, calving weight, growth of mammary tissues, milk production and postpartum anestrous in cows (Funston *et al*., 2010; Allen *et al*., 2012) [27, 2].

Bedding/floor materials and comfort of dairy cows

The quality of bedding material provided to the animals can also be evaluated by the number of lying bouts (Manninen *et al.*, 2002) [41]. The comfort level of cow is more on soft bedding as compared to harder and cows prefers to lie on soft beds (Tucker and Weary, 2004; Fregonesi *et al*., 2007) [62, 26]. Moreover, the duration of feeding is also higher in former as compared to later (Tucker *et al*., 2006) [64]. The cow comfort index (CCI%) is the proportion of cows lying down comfortably in stalls, when assessed in crossbred cows in concrete floor and with sand as bedding material, during two different seasons i.e. winter and hot-humid season, it was observed that cows were in more comfort in sand as bedding material as compared to concrete (Winter, 87.55% vs 81.88%; Summer, 95.42% vs71.67%). Moreover, the milk yield is also higher in case of former as compared to concrete floor (Joshi, 2014) [34]. Similar observation was also observed by Haley *et al*. (2001) [28] in H.F. cows, where lying duration is more in rubber mattress as compared to concrete floor (51.0% vs 43.4%) with less standing time (11.04 h vs 12.87 h). However, some researchers found that neither rubber mat nor sand alone affects the milk quality and quantity, but their combination shows better performance as compared to concrete alone, concrete with brick paving, concrete with sand (Upadhyay *et al*., 2015) [67]. In general, most of the researchers had observed lesser lying and greater standing times when dairy cattle are housed on hard surfaces like concrete (Haley *et al*., 2000; O'Connell and Meaney, 1997; Rushen *et al*., 2001) [29, 46, 51]. However, when concrete floor is covered with some soft bedding material, the duration of lying is almost similar to that of rubber mats (Wechsler *et al*., 2000; Manninen *et al*., 2002) [70, 41]. Many authors found that bedding with straw is more comfortable than rubber mattress flooring (Madke *et al*., 2010) [40] with greater duration of feeding, rumination and resting. Moreover, in unheated buildings during winter season, straw bedding increases thermal insulation in cow stalls (Tuyttens, 2005) [66]. However, dairy cow prefers plenty of straw with concrete floor and small amount of straw with rubber mats both in winter and summer season as compared to sand beddings (Manninen *et al*., 2002) [41]. In a preference test, Tucker *et al.* (2004) [62] observed 7.5 kg straw is preferred by dairy cows as compared to less quantity of straw. Similarly, Calamari *et al.* (2009) [8] observed that a lactating cow prefers to spend about 44.1% of lying time as compared to other bedding materials and concluded sand as best lying surface as compared to other bedding materials. However, Norring *et al.* (2010) [44] concluded rubber mat as best material in comparison to concrete stalls (73 vs 18 observations/day) and sand (50 vs 40 observations/day). But, at the time of calving, sand bedding is more preferable than concrete and rubber mats (Campler *et al*., 2011) [9]. Sand has been considered as "gold standard" bedding material because it is economical, improves cleanliness, does not supports bacterial growth, have uniform size, non-absorbent in nature and provides good traction to cows, thus better leg health (Espejo *et al*., 2006**;** Norring *et al*., 2008) [23, 45]. In Nilli Ravi buffalo, the lying and milk yield is highet when sand is used as bedding material in comparison concrete alone and with paddy straw (Raza *et al*., 1998) [49].

Besides the type, depth of bedding material is also one of the factors for cow's comfort. Laying surfaces which are deep bedded provides more comfort than shallow bedded for lame cows (Jensen *et al*., 2015) [32]. The sand bedding with minimum depth of 25 cm is found to be suitable for many researchers (Buli *et al*., 2010; Cook, 2010) [7, 17]. Similarly, size of bedding material also influences the dairy cow performances *viz.* Small particle size of saw dust is associated with greater incidences of *Klebsiella* mastitis, moreover, the bacterial count is lowest in sand surface having size of 25 mm (Buli *et al*., 2010) [7]. Uneven small or large size causes discomfort to animals, either by causing leg injuries or by sticking to the teat ends. Increasing the depth of bedding material increases the cost of bedding, however, simultaneously, it also increases the comfort level of dairy cows. It has been observed that lying time increases by 13 minutes and 3 minutes by adding each extra kilogram of straw and wooden shavings respectively (Tucker *et al*., 2009) [65]. Similarly, the requirement of straw is more with concrete floor as compared to rubber mattress for improvising the duration of lying (Jensen *et al*., 1988) [33].

Bedding/floor materials and reproductive performance of dairy cows

The reproductive performances of dairy cattle largely depend on type of flooring material, with lameness being one of the most common reasons, along with other stressors such as, reduction in duration of lying (Caraviello *et al*., 2006; Fregonesi *et al.*, 2007) [10., 26], reduced feed intake (Schefers *et al*., 2010) [53], thus lowering the BCS. Such stress adversely affects reproduction at a physiological level. The activities related with reproduction *viz*. number of mounts and estrous duration is generally significantly better in soft surfaces like rubber-covered slats, pasture and straw in comparison to concrete floors. However, housing of dairy cows in compost bedded pack resulted in reduction in calving interval, days open and higher milk production than convenient bedding housing (Kara, 2011; Black *et al*., 2011) [, 4]. In straw used calving pen subclinical endometritis was 10.7% lower compared to other type bedding like paper, sawdust or sand (Cheong *et al*., 2011) [13].

Lameness

The lameness has a direct negative effect on profitability of a dairy farm (Cha *et al*., (2010) [11], Peake *et al*., 2011) [47], as it directly affects the milk yield and reproductive performance of dairy cows. The effect of lameness associated with reduced milk yield, premature culling, and increased calving to first service time, fertility problems and huge economic loss etc. Many factors like genetics, stage

and parity of lactation and body weight are related to lameness but environment and bedding quality are the most important factor for lameness. The important floor characteristics like quality, friction, shape and cushion also affects the limb health. Incidence of lameness on dairies varies according to housing type, time of year, and stall surface. Prolonged standing on concrete is a major predisposing factor for lameness (Singh *et al*., 1999). The hardness of floor results in lameness problem due to damage of white line damage and horn lesion (Choudhary *et al*., 2025) [15]. Among dairy animals, the incidences of injury due to slipping was higher in fully slatted concrete floors as compared to perforated floor or perforated floor with rubber mattress (Cozzi *et al*., 2013) [18]. Similarly, the problems associated with sole haemorrhages are less in rubber flooring and highest in concrete floors (Haufe *et al*., 2012) [30]. The injuries of claw have negative impact on production and reproduction of animal (Enting *et al*., 1997) [22].

Conclusion

In conclusion, bedding materials has potential impact on the important economic traits in dairy animals. Sand is the best bedding material according to the different previous research finding, which is not only comfortable, but being inorganic nature, also permits lowest contamination of various microbial agents. It results in lower SSC and it is helpful to reduce the productive and reproductive problems. Since, bedding of sand aids more cushion, support and traction, thereby reducing the problems associated with lameness. In many experiments, rubber flooring is also better for reproductive performance and mounting behaviour. The lameness imparts the negative effects on profitability of a dairy farm. An ideal bedding material should be comfortable, dry, clean, absorbent, cost effective and inert. Other different types of floor can also be used only after essential modifications. Good management can eliminate the disadvantage whereas bad management can override the advantageous of bedding materials.

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