



A Review: Effect of Bedding Material on Production, Reproduction and Health and Behavior of Dairy Animals

Amit Kumar Singh^{1*}, Tripti Kumari¹, Manmohan Singh Rajput¹, Anusmita Baishya¹, Ninad Bhatt¹ and Surjyakanta Roy²

¹Ph.D. LPM Scholar, Livestock Production Management Division, National Dairy Research Institute, Karnal, Haryana, INDIA

²PhD Agriculture Extension Scholar, Agriculture Extension Division, Indian Agricultural Research Institute, New Delhi, INDIA

*Corresponding Author: amitkumarsingh5496@gmail.com

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Abstract

Proper housing is necessary to obtain improved production, reproduction, health performances along with the well-being of dairy animals. Proper bedding is an inevitable part of proper housing. It provides overall comfort, encourages production performance, and helps in avoiding injuries and lameness to the dairy animals. It is equally important to have proper bedding for better udder health of dairy animal. There can be various bedding materials for the animals like sand, wood shavings, rubberized mats, concrete floor, saw dust, straws, etc. Selecting a good bedding material is always advisable for better health, production and reproduction performance of dairy animals. New approaches are being made to enhance the comfort level of dairy animals for which they are provided with suitable bedding materials. Selection of bedding material may depend also upon various climatic conditions. This review article enlightens the important research works done in this field for better understanding and selection of proper bedding material for dairy animals.

Keywords: Bedding Materials, Dairy Animals, Health, Production, Reproduction

Introduction

In last two decades the focus on better quality milk production and well-being of animals have become the priority of many modern farms. Better management conditions may improve the performance of dairy animals (Singh *et al.*, 2020a; Singh *et al.*, 2020b). Good farm management should be adopted to increase the farm profitability (Kumari *et al.*, 2020; Singh *et al.*, 2020c). To ensure longevity and long-term productive capability of dairy animals it is necessary to provide healthy and comfortable environment to them. For this, highly mechanized farming practices are coming into play which intensifies the animal production systems. In recent years, efforts have been made to improve welfare and overall-health of dairy cows by adding a higher level of comfort regarding the housing environment (Mishra *et al.*, 2017). It has been investigated that housing system and resting surface have influence on milk yield and reproductive performance similar to feeding and keeping methods in dairy herd (Singh *et al.*, 2020d). Good bedding and flooring provides comfortable area for animals to take rest and it also helps to improve health and productive performance. Bedding improves the physical comfort of the floor (MauriceTuytens, 2005). Moreover, resting is prioritized over other behaviors by dairy cows. Cows that are deprived of lying show behavioral and physiological disorders (Thomsen *et al.*, 2012) which may be unpleasant and unhealthy for dairy animals. Furthermore, it was remarked in a latest study that bedding material may introduce bacterial count in milk (Bradley *et al.*, 2018) leading to a potential concern for both human and animal health. Bedding material may be used as a flooring material. It provides comfort to animal, encourages resting, contribute to udder health, milk quantity and quality. It may also help in subsidizing injury and fatigue. Different factors involve in selecting a proper bedding material for dairy animal housing. Availability of bedding materials should also be given importance while bedding material selection. Climatic conditions of a particular region may considerably influence the type of bedding material.

Proper reviews covering the different bedding materials on performances of dairy cows are very scanty. Therefore, the present review has been made to cover latest studies done on production, reproduction, health, well-being and behavioural aspects of dairy cows under different types of bedding materials.

Types of Bedding Material

There may be broadly two types of bedding materials namely, Organic and Inorganic bedding materials. Organic bedding materials includes straw, wood shavings, hay, crop residues, saw dust (Bradley *et al.*, 2018), composted manure, wood chips (Chamberlain, 2018), etc. On the other hand, inorganic bedding materials include sand, limestone, gypsum, rubber mattresses (Bradley *et al.*, 2018), cement, etc. Wood shavings are generally mixed with sawdust for improved aeration, compact ability, improved tilling process (Janni *et al.*, 2006). Chipped wood usage as bedding material may lead to injury due to sharp edges (Bewly *et al.*, 2013).

Organic Bedding Materials

Pros	Cons
Absorb moisture	Reservoir of bacterial population
Compatible with manure handling systems	Supports rapid bacterial growth
Readily available	Mastitis infection is more
Cheaply available	May lead to foul smell

Inorganic Bedding Materials

Pros	Cons
Inert in nature	Not readily available
Does not support the growth of bacteria	Not compatible with manure handling systems

Bedding Material's Characteristics

Comfort

First and foremost aim of bedding material is to provide overall comfort to the animals. It should promote the

productivity and well-being of animal.

Particle Size

Particle size depends upon the type of bedding material. For sand it is 0.1 to 2mm, for wood shavings it is 2-4cm. Large sand particle can cause discomfort and even injuries to animals whereas, very fine particles like that of sawdust may cling to the animal's skin and teats thereby causing itching and may cause contamination with pathogens.

Moisture

Bedding material should be kept as dry as possible. Wet materials may become breeding place for microbes which may be unhealthy for the animals. Wetness of bedding material depends upon the particle size. Small particle size coupled with moisture makes it dense and compact. Moisture characteristic is the main driver of environmental mastitis to dairy animals when bedding is concerned (Fávero *et al.* 2015). It is difficult to control especially when the ventilation facility is poor in animal house (Lobeck *et al.*, 2011; Black *et al.*, 2014). Proper ventilation and sunlight exposure facility in animal house may help in adequately reducing moisture levels in bedding (Galama *et al.*, 2015; Leso *et al.*, 2020). Bewley & Taraba (2013) recommended 40 to 60 % moisture in upper 15 cm layer of bedding material.

Availability

Bedding materials should be economical (Leso *et al.*, 2020), easily and locally available. Composted bedding material may be required for area of 6m²/cow to 15 m²/cow for free walking (Leso *et al.*, 2020).

Inert

Bedding should not encourage bacterial growth, but organic matter such as wood shavings, straw and paper byproducts do. They should be unpalatable to animals. Regular changing of bedding on an average of a week is suggested if organic materials are incorporated. Depth of bedding may vary from 20 cm to 1 m as per the management practice of the farm (Leso *et al.*, 2020). However, (Bickert *et al.*, 2000) suggested that a minimum of 15 cm bedding is necessary for good performance of dairy animals.

Climatic Conditions and Bedding Materials

Free stall barns require lesser bedding materials, provided better overall health in hotter climates than composted bedding. Additionally, free stall barns are easier to manage than compost bedded barns (Bickert *et al.*, 2000). Composted bedding can be utilized in hot- humid conditions provided fan conditioning should be there (Bewley & Taraba, 2017). Asian country's dairy farms are coming up with free stall designs (Chamberlain, 2018). Chamberlain (2018) also proposed in his review that in near days composted bedding will be tested for Australian climatic conditions. However, there is a lack of research for composted bedding under tropical type of climate.

Effect of Bedding Materials on Health and Performance of Dairy Animals

It was found that bedding material does not affect body condition score (BCS) of dairy cows and also similar hygiene score was noticed amongst different bedding materials in the barn (Shane *et al.*, 2010). Poorly managed and confinement housing can have the potential for environmental mastitis in milking cows as it exposes teats to high levels of bacteria which may be present in the bedding material (Faull *et al.*, 1996). Organic bedding materials tend to contain higher levels of environmental bacteria, and bulk milk somatic cell than inorganic materials (Godden *et al.*, 2002; Rowbotham & Ruegg, 2016). It is reported that cows kept on concrete also had a higher risk of developing heel erosions and were more likely to become lame, show higher claw growth and wear (Vanegas *et al.*, 2006). Health parameters like teat and udder wound, mastitis, fever and uterine infection cases were more in number in concrete floor as compared to sand bedding material (Kumar *et al.*, 2017). Mastitis is considered as one of the most devastating problem for dairy industry (Kansal *et al.*, 2020; Kumari *et al.*, 2019; Bhakat *et al.*, 2017). Udder injuries or mastitis disease cases were found least in case of sand followed by rubber mat and concrete floor bedding materials (Madke, 2007). Fecal prevalence of *Escherichia coli* was found to be less in case of sand bedded animal

as compared to saw dust bedded animals (Westphal *et al.*, 2011). Flitz *et al.* (1978) observed the behavior of dairy cows (German Black Pied, German Red Pied and Holstein- Friesian) which revealed that daily 4 % FCM yields in winter were significantly higher in deep litter housing as compared to stall fed housing. In a study, Black *et al.* (2013) found significantly higher milk in compost bedded (CB) cows than non CB cows.

Highest ammonia concentrations were seen in sand bedded animals whereas methane was emitted most in composted bedding materials as compared to straw, free stall, wood chips as bedding materials (Leso *et al.*, 2020). Reason behind high ammonia emission in sand bedding may be due to absorption of more urine and faeces whereas more methane emission in composted bedding may be due to the presence of more decomposed organic materials.

Bedding, Floor Type and Lameness

The effects of lameness, for the profitability of a dairy farm, are negative (Cha *et al.*, 2010). Prolonged standing on concrete is a major predisposing factor for lameness (Singh *et al.*, 1993). Reports show that cases of recovery of hook lesions, lesion severity, hoof lesion score, sole haemorrhages, heel horn erosions were found less in sand bedded animals as compared to straw bedded animals (Norrington *et al.*, 2008). Usually hoof lesions are associated with lameness cases in dairy animals (Kester *et al.*, 2014) which has the potential for economic loss and poor welfare. Kester *et al.* (2014) suggested that hock lesions may occur in dairy animals out of several reasons such as lesser feeding space (Rutherford *et al.*, 2008), lameness, no grazing facility, poor bedding in stalls of animals or it may happen due to pathological conditions. High friction and abrasive hard bedding surfaces may lead to hook lesions (Brenninkmeyer *et al.*, 2012). In addition to this if upward projections are present over the bedding surface, on continuous rubbing with animal body may lead to the formation of lesions over the skin too (Kielland *et al.*, 2009). Rutherford *et al.* (2008) also remarked that the cows mated in early age (15 months) were at higher risk of hoof lesion. Furthermore, Van Gastelen *et al.* (2011) reported higher prevalence of hock lesions on farms in which foam mattresses was used as compared to farms using box compost, sand, or horse manure. Dermatitis, heel horn erosion, white line hemorrhage, sole ulcer, white line separation cases were seen lesser on hoof health of tied dairy cows in rubber slatted floor as compared to hard floor (Hultgren & Bergsten, 2001).

Hook lesions have been found associated to other health problems such as skin lesions, teat alterations, joint problems, increased somatic cell count (SCC) (Regula *et al.*, 2004; Fulwider *et al.*, 2007) haemorrhages, swelling and scabs (Livesey *et al.*, 2002). This may lead to discomfort to dairy animals thereby adversely affecting their overall performance. Premature culling, prolonged calving interval, cost of labour and treatments, change in milk fat, and milk yield, unproductive future income may be the effect of lameness in dairy cows (Peake *et al.*, 2011). Risk of hook lesions is more prevalent in high producing cows than lower ones, especially during later stage of lactation (≥ 270 days) (Potterton *et al.*, 2011; Kielland *et al.*, 2009), and increase in lactation number (Rutherford *et al.*, 2008).

Bedding Material and Reproductive Health

Association of repeat breeding cases with bedding material revealed that concrete floor had most cases followed by sand and rubberized bedding material. Dystocia and Retained placenta cases were more in concrete and rubberized floor and least in sand bedding (Kara *et al.*, 2015). Gny and Utvinczuk (1993) observed more fertility rate in cows housed with litter as compared to that in without litter housing. Lower somatic cell count (SCC) and higher oestrus detection rates were shown in CB cows. Mounting activity for oestrus detection was markedly inhibited by slippery floors than rough floor; however, softer floor like pasture based is preferred over hard bedding like concrete for proper mounting activity (Palmer *et al.*, 2010).

Effect of Bedding Materials on Behavior of Animals

Lying is an important behavior for cattle occupying approximately 50% of their daily time budget (Krohn & Munksgaard, 1993). Cows prefer to lie down on soft bedding materials. It was found that number of lying bouts can be considered as an important indicator of the quality of the bedding material provided (Manninen *et al.*, 2008). Further, lying times are lower and standing times are higher when dairy cow forced to use hard surfaces, specifically concrete (Haley *et al.*, 2001). It was seen that dairy cow prefers dry bedding more as compared to wet bedding and it was also seen that cow lie down for more time during winter season than summer season (Reich *et al.*, 2010).

Daily Time Budget for Lactating Dairy Animals (Grant, 2004)

- 1) Eating 3 to 5 hr (9 to 14 meals/day)
- 2) Lying/resting 12 to 14hr
- 3) Ruminating 7 to 10 hr
- 4) Drinking 30 min
- 5) Management activities 2.5 to 3.5 hr
- 6) Social interactions 2 to 3 hr

Table 1: Effect of modified housing system on behavior of crossbred cows under different seasons (Sinha, 2015)

Behavioral Parameters	Hot Humid Season		Autumn Season	
	Modified (Sand)	Existing (Concrete)	Modified (Sand)	Existing (Concrete)
Sitting time	9.57	8.4	10.14	9.12
Standing time	8.41	9.59	8.19	9.24
Standing rumination	1.24	1.38	1	1.05
Total rumination	7.13	6.31	7.01	6.15
Duration of lying bouts	1.11	1.05	1.16	1.1
Feeding bouts	8.61 ^A ±0.20	9.63 ^B ±0.32	10.31 ^a ±0.41	10.69 ^b ±0.43

Sitting time, standing time, standing rumination, total rumination, duration of lying bouts (hr/day); feeding bouts (numbers/day)

Table 2: Distribution of time spent in shed (%) on various activities of the crossbred cows housed under sand and concrete floor in hot-humid and autumn season (Sinha, 2015)

Shed Type	Season	Sitting Idle (%)	Sitting Rumination (%)	Eating Time (%)	Standing Rumination (%)	Standing Idle (%)
Sand	Hot humid	22	31	30	8	9
	Autumn	23	32	30	5	10
Concrete	Hot humid	19	30	29	7	15
	Autumn	22	27	29	6	16

From Table 1 and Table 2 it is clear that modified housing (sand) showed more comfort activities like lying, lying ruminating, sitting ruminating and lower standing time. However, higher standing time represents discomfort. Sand bedded animals had significantly lower feeding bout which represents more comfort to the animals of sand bedded animals as compared to that of concrete floor. Mattachini *et al.* (2019) showed that high feeding bouts shows discomfort to dairy cows whereas group of animals which had lower feeding bouts produced significantly higher milk than high feeding bout group.

Importance of Different Bedding Materials for Dairy Animal

Inorganic materials, namely sand, have been considered as the *gold standard* for bedding material (Justice-Allen *et al.*, 2010). Sand is inert; it can be recycled and reused as bedding (Van Gastelen *et al.*, 2011). It does not support bacterial growth (Godden *et al.*, 2007). Sand is also non-absorbent, which means that it does not retain or soak up urine and leaked milk (Gooch & Inglis, 2010) which hinders bacterial growth. Moreover, it is found that bacteria types and counts found in bedding materials have a positive correlation with the bacteria types and counts present on the teat end (Zdanowicz *et al.*, 2004). Lowest case of mastitis found in sand bedded animals (Bey & Reneau, 2002). Increased milk yield may be observed in free stall pens with sand than without other type of sand bedding (Calegari *et al.*, 2012). Sand bedding reduces the development of new cases of lameness. A depth of 25 cm has been suggested, with complete sand bedding replacement necessary every 12 to 14 days (Cook *et al.*, 2010). Particle size should be 0.1-1mm and of uniform in size (Schoonmaker, 1999).

Organic husbandry practices are found effective for hoof health maintenance. Rutherford *et al.*, (2008) suggested for use of straws as bedding material for better hoof health. Cows have been seen to prefer straw bedding than sand,

lying time was found more on straw than sand. However, hoof health and cleanliness maintenance was better in sand as compared to straw bedding (Norrington *et al.*, 2008) thus poorer udder health in straw bedded animals (Leso *et al.*, 2020). Addition of lime powder, formaldehyde-based compounds may decrease the risk of health hazards (Patterton *et al.*, 2011). Mattresses were introduced for bedding of dairy animals however they were found to compromise the cow comfort, increased risk for hoof lesions, and lameness (Cook *et al.*, 2004 ; Fulwider *et al.*, 2007). Rubber mats are comparatively costlier than above mentioned bedding materials, it may lead to undesirable overgrowth of claw (Platz *et al.*, 2008). Leso *et al.* (2020) remarked that composted bedding than free stall or straws may improve overall cow comfort, better leg health, better expression of natural behavior, and improved manure quality of dairy cows.

Recycled Manure Solids (RMS)

Recently, survey was done to see the suitability of recycled manure solids (RMS). It was found that RMS was used successfully by farmers in US as an alternative source of bedding material for dairy cows having comparative SCC (Husfeldt *et al.*, 2012) as compared to raw and undigested bedding materials but, farmers are suggested to be cautious regarding maintenance of strict hygiene, milking practices and closely monitor its effects on herd health (Leach *et al.*, 2015). (Lobeck *et al.*, 2011) found that during autumn season it is difficult to maintain the cleanliness of cows. As several recent researches done on usage of RMS suggest that it may be more favorable for the growth of environmental pathogens as compared to other bedding materials (Rowbotham and Ruegg, 2016; Bradley *et al.*, 2018). Recommended dry matter in RMS is > 34% (Bradley *et al.*, 2018). More moisture percentage in RMS may lead to adverse circumstances towards economic aspect of farm (Fávero *et al.*, 2015).

Conclusion

Cow comfort is an essential management practice. Bedding improves productive and reproductive performance. Selection of proper bedding material should be considered equally important as housing. The bedding materials used in cow stalls needs to be dry and clean to reduce potential risks for mastitis. Bedding material has a high impact on walking and lying comfort of dairy animal. RMS has been introduced recently seeing its positive impact on health and performance of dairy animals however, one should be cautious while considering its usage under different micro and macro environmental conditions. Providing soft bedding materials such as straw, sand, mattress than conventional concrete floor reduces the chance of lameness and improves the reproductive performance. Composted bedding may be used as an alternative for free stall or straw based bedding. Composted bedding performed better than other in most of the climatic zones, however studies are required for tropical climates. Locomotory activities on soft beddings have found to enhance hoof health. Grazing facility in addition to proper bedding may improve production and reproduction performances of dairy cows.

Conflict of Interests

There is no conflict of interest.

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