



Review Article

IMPACT OF FLOOR TYPE AND BEDDING MATERIALS ON UDDER HEALTH, REPRODUCTIVE PERFORMANCE AND LAMENESS IN DAIRY ANIMALS: A REVIEW

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Received: July 25, 2016; Revised: August 11, 2016; Accepted: August 12, 2016; Published: October 27, 2016

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. To intensify the productivity, animal production systems are becoming highly mechanized. Housing system and resting surface have influence on milk yield and reproductive performance as much as feeding and keeping methods in dairy herd. Different types of bedding materials are used by livestock owners according to their availability, waste management, ease to use and cost. Good quality bedding materials contributes to better health and cow comfort. In recent years, many efforts have been undertaken to improve health and performance of dairy animals by modifying the housing environment. This review will be helpful for selecting bedding materials for better health and performance.

Keywords- Lying, Bedding, Lameness, Milk, Microorganism

Citation: Gupta Shailesh Kumar, et al., (2016) Impact of Floor Type and Bedding Materials on Udder Health, Reproductive Performance and Lameness in Dairy Animals: A Review. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 51, pp.-2364-2368.

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Academic Editor / Reviewer: Dr A. Bora

Introduction

Different types of bedding materials like straw, limestone, sand, sawdust, wood chips, newspaper, manure solids, rice hulls, etc are used for dairy animals. In different countries, dairy farmers prefer different floor type like rubber, stones, gravels, bricks, concrete, mats and mattress etc. according to their own status. Poorly designed stall and bedding facilities causes increased risk of productive, reproductive performance and lameness. Housing systems is directly correlated with performance of dairy animals. Bedding materials and cow excreta (urine, dung, manure) has also impact on the microbial growth, resulting in mastitis problems. Provision of hard and unsuitable bedding in resting area resulted in lameness and leg injuries. Dairy cows always prefer stall with dry bedding than stall with wet bedding. Proper bedding and flooring provides soft area for animals to lay for rest and help to improve their performance. Some bedding materials act as a thermal insulator during summer season. Various researches were conducted previously for selection of better bedding materials and floor type. The new finding and suggestions of experiments are discussed below.

Relationship between daily time budget, cow comfort and performance of dairy cows

Proper rest has direct effect on performance of dairy animals as bedding and flooring provides soft area for animals to lay for rest and thus helps to improve their productive and reproductive performance. Dairy cows prioritize resting over other behaviors and cows that are deprived of lying shows behavioral and physiological disorders. [Table-1] shows a daily time budget for a dairy cow, suggested for better performance and health.

About 12-14 hours per day of lying/standing is essential for better health and different performance parameters of dairy animals. So, we can conclude that lying

behavior occupies about 50% of their daily time budget [2].

Table-1 Daily time budget for a dairy cow [1]

Activity	Time/24 hours
Lying/standing	12 to 14 h
Eating	3 to 5 h
Drinking	30 min
Rumination	7 to 10 h
Social interaction	2 to 3 h
Managerial activities	2.5 to 3.5 h

A lying time of 11 hours per day in free stall system is adequate for a lactating cow [3]. Lying time ranges from 8 h/d in pasture [4] to 12.5 h/d in tie stall [5]. A resting time of 10 hours per day with deep straw-bedded yard is adequate lying time for a dairy cows [6]. Phillips and Rind (2001) suggested a lying times of 10.9 to 11.5 hours per day in different type of housing system [7]. The important factors which direct affects the lying behaviors are social rank, health status, housing system, lying area design, overstocking, management and season. It also affected by daily milking management practices like, milking time, milking periods and waiting periods etc. Lying time is higher during winter season than summer [8]. Increased lying may be helpful in more supply of blood to the udder [9], up to 24-28% more as compare to standing animals [10]. A higher blood flow in the mammary gland was reported during the laying period as compared to standing (4.56 l/min vs. 3.56 l/min.) [11]. Laying deprivation resulted in stress to dairy animals, which affects

productivity and physiological status. Such type of stress results in low level of growth hormone with elevated level of plasma cortisol level. Reduced lying time results in low feed intake and lower milk production. High producing dairy cow requires more time for eating to produce more milk. Cow spends more time in feeding when soft and comfortable bedding materials were provided [12].

Soft bedding materials increases cow comfort. Many previous researches showed that cow prefer soft beds for lying [13, 14]. In a comparison of H.F. cow's performance in concrete and mattress bedded flooring materials, it was found that the animals in mattress floor spent more time in lying (51.0% vs. 43.4%) and less time for standing (11.04 ± 3.68 vs. 12.87 ± 0.42) [15]. Dairy animals prefer stall with large amount of bedding materials [16]. Similar type of result was observed in animals with tie stall and larger pens with mattresses where large stall animals spent more time for lying (14.73 ± 0.91 vs. 10.51 ± 1.03) [17]. Many authors found that straw bedding was good for bedding. Use of straw bedding is more comfortable than rubber matters and rubber flooring [18]. In straw bedding feeding, rumination and resting time was significantly higher. It was also reported that dairy cow prefers straw and rubber mats both in winter and summer as compared to the sand bedding [19]. Many preference tests were conducted for dairy cows to evaluate their choice for floor type. In a preference test, it was observed that a lactating cow spent about 44.1% of the total lying time in sand than other bedding [20]. In another observation, it was found that out of seventeenth cows, ten cows preferred sand bedding than concrete and rubber mat during calving time [21]. Lying time was also higher in sand bedding. Sand is called "gold standard" among all type of bedding material [22,23] and more comfortable for cows [24]. Nilli Ravi buffalo preferred sand bedding and lying time was also higher in animals with sand than concrete and concrete floor with paddy straw [25]. However, some reports are contrary to these findings. Dairy cow spent more time in the rubber mate bedding as compare to concrete and sand (768 min. vs. 727 min. and 707min) [26]. In case of Holstein dairy cows, rubber mats with small amount of straw bedding are more comfortable than manure-straw bedding and sand [27].

Depth and height of bedding materials is also a important factor for dairy cows comfort. A minimum of 25 cm depth of sand bedding is suggested by many authors [28,29]. Deep bedded laying surface also provides more comfortable to the lame dairy cows [30]. More than 2 cm. height of bedding materials or sand bedding increases lying time 1.44 and 0.06 hours/day [31]. Very small or large size sand particles can cause discomfort to the animals. Abnormal size may result in wound in legs or stick the teat ends. Bacterial count and moisture content is lowest in the surface with 25 mm of sand bedding material [32]. Generally, a large amount of bedding materials is required in deep litter system than the free stall and tie system. But, increasing the amount of bedding materials in the stall is more comfortable for dairy cows. Addition of each extra kg of shavings and straw results in increasing of the lying time by 3 minutes and 13 minutes respectively [33]. Many researchers suggested different amount of bedding materials according the local environment. In case of lactating animals, a 5 to 8 kg and 20 to 25 kg of sand is best for dairies of Europe and United State condition respectively [28]. In place of sand, we can use 3 kg saw dust per cow /day and 5 kg straw per cow/ day as top dressing [22]. Similarly, a concrete floor provision of 4 to 5 kg of straw and little straw with mattresses is better for maximizing the lying time [34]. Modifications in normal daily behavior are also helpful to increasing daily laying time. A standing deprivation of 4 hours per day is also helpful to increase the laying and sleeping time in dairy animals [35].

Bedding materials and microbial growth

In bedding materials, presence of large number of different types of bacteria results in mastitis and increased somatic cell count [SCC] in milk. Mastitis is an economically important disease, which directly affects the quality and quantity of milk. Generally, in a dairy cow herd, incidences of sub clinical mastitis is generally more than clinical mastitis and accounts ranges from 19 to 78 percent [36]. Sub clinical mastitis is associated with prevalent type of udder infections in dairy cows. In Indian condition, incidences of subclinical mastitis are more about 10-50% in dairy cows. A loss of about 70% in milk yield during to mastitis condition [37]. Organic bedding materials contain higher number of environmental bacteria than

inorganic materials. Inorganic bedding material is also a best for cow comfort. SCC is less in the inorganic bedding materials [38]. Inorganic materials requires less changing than organic bedding. Bacteria types and counts found in bedding materials have a positive correlation with the bacteria present on the teat end [39]. In teat canal, different causative microorganism produces toxic substances, which directly affect mammary gland cells. Udder and teat conformation traits found to have a narrow relation with mastitis resistance and milk SCC [40]. The Incidence of mastitis is higher when teat is more close to the floor [41]. The main causative spp. of mastitis are *Staphylococcus*, *Streptococcus*, *Enterobacter aerogenes*, *Proteus*, *Klebsiella*, *Pseudomonas*, *Escherichia coli*, and *Serratiamarcescens*. *Escherichia coli* O157:H7 is a major fecal microorganism causes mastitis during the summer season. A large number of *Streptococcus* species may present in animals surrounding environment. Generally, SSC of less than 200,000 cells/ml is considered as normal milk. More than this value is a indicator of microorganism infection. In many previous finding coliform bacteria and *streptococci* spp. are responsible for mastitis infections [42] but in India, *Staphylococcus aureus* is mainly responsible for mastitis [43]. Recently, a mastitis causing algae *Prototheca* spp. is identified which is responsible for increasing SCC count and reduction in milk yield [44]. *Prototheca* spp. can survive in a wide range of environmental conditions and may avoid bacterial reducing disinfectants. Slow growth of prototheca was observed in Spruce shavings than sand, manure and sawdust [45].

The physical and nutritional conditions of bedding materials also affect the growth of microorganism. A close relationship is observed between quality of bedding material and bacterial population. Coliform and total bacterial counts activities are higher in indoor housing than outdoor or pasture. Manure bedding supported the growth of microorganism as it contains large amount of nutrient. In a study of 38 dairy farms, it was found that recycled manure solid was being used as bedding materials because SSC was lowest than other bedding materials [46]. Daily replacement of manure bedding from the stall reduces the total bacterial counts [47]. Drying of manure bedding before application in the stall also reduces the number of microbial content in the bedding. Recycled bedding materials can be used as the surface application on the top of floor or as a deep bedded packs. Contrary to this composted bedding material is less favourable to microorganism growth and coliforms, *Streptococcus* and *Klebsiella* growth was found lower than fresh recycled manure [48]. Sand is a inorganic bedding materials which that have lowest bacterial count. Sand bedding materials contain less bacterial count ($1.2 \text{ cfu} \pm 1.6/\text{g}$) than foam mattress ($15.7 \text{ cfu} \pm 11.0/\text{g}$), box compost ($17.8 \text{ cfu} \pm 19.4$) and horse manure ($110.5 \text{ cfu} \pm 86.3/\text{g}$) [49]. *Coliform* and *Klebsiella* bacteria population were 2 times and 6 times more respectively in sawdust bedding compared to sand bedding [39]. It was due to small particle size and high water holding capacity of saw dust than any other bedding materials resulted in rapid growth of bacteria. So some author suggested for drying of saw dust before use. These two bacteria were also higher in newspaper bedding than sand and lime bedding [50]. Use of newspaper is advantageous as papers are inert in nature initially but it and become contaminated after come in contact with dung and urine. In a 1800 sample of feces from different dairy farms it was found that prevalence of mastitis is lower in sand bedded animals (1.4%) as compare to saw dust (3.1%) [51]. Lowest case of mastitis was found in the sand and rubber floor bedded animals than concrete floor bedded animals. The lowest clinical mastitis case was observed in rubber flooring than concrete and sand bedding [52]. It was also found that rubber flooring is better to reduce the chance of clinical mastitis. The case of clinical mastitis was 14 percent higher in concrete floor than rubber mats [53]. In a comparison of the effect of deep bedded new sand, recycled sand and manure solid on mastitis incidence in primiparous Holstein cows, it was found that quarters of new sand bedded animals have more survival time for clinical mastitis than other two bedding [54].

Acidic bedding conditions is low favorable for growth of mastitis pathogens. Normally, a pH above 4 is most favourable for environmental bacteria growth. *Klebsiella* spp. are generally present in soil, bedding and water trough and responsible for mastitis through teat canal infection. Godden *et al*, (2008) compared the different type of bedding materials for mastitis supporting microorganism *Klebsiella pneumoniae* and *Enterococcus faecium* [55]. They

reported that lowest pH was found in the wood shavings and clean sand. Lowest C% and N% was lowest in the clean sand. A ratio of C: N should be 25:1 to 30:1 for compost bedding [56]. These conditions were not favorable for the microorganism growth in the sand. They found a reduced bacterial growth in *Klebsiella pneumoniae* in clean sand whereas *Enterococcus faecium* growth was negative or in dead growth phase in clean sand and wood shavings. The use of hydrate lime resulted in increased pH and low H₂O content in saw dust and shavings. The use of acidic and alkaline conditioner has been effective to reduce the bacterial counts in the bedding materials [57]. Different bacteria like *S. aureus* *K. pneumoniae* etc. can be inhibited by low to higher concentration of red cedar shavings and iodine. Clay based bedding also inhibited the growth of microorganism due to its acidic nature [58]. Different external and internal teat sealer are also available in market, which may reduce the chance of teat infection. Use of Bismuth subnitrate and Dry Flex (internal teat sealer) is effective tool for controlling teat infection [59] [60]. Use of teat sealer along with long acting antibodies reduces intra-mammary teat infection with better action. Just after milking the teat infection incidence is significantly higher than latter. In management practices increasing of post milking standing time have a significant role in reducing the chance of bacterial infection through teat orifices [61].

Milk yield and its compositional quality

Milk yield and its compositional quality directly depend on udder health and its immunity [62]. No any positive effect was observed related to milk parameters in many experiments. Non-significant effect of rubber or concrete floors was observed on different milk parameters [63, 64]. Similarly, no any significant effect of bedding materials was observed on milk yield and milk composition in Vrindavani cross bred cow (HF/Jersey/BS X Hariana) [65]. Kremer (2012) had observed that Milk yield, fat yield, fat %, and Protein yield was non-significantly increased by using rubber mat than concrete floor. He reported that only protein % significantly increased in rubber mat but no any specific cause was observed during experiment [Table-2] [66].

Table-2 Productive performance of dairy cows on concrete slatted flooring group (CSF) and rubber-matted slatted flooring group (RSF) [66].

Milk yield	CSF	RSF
Milk, kg	3136.5±125.9	3088.9±117.4
Fat, kg	127.1±5.5	122.8±5.1
Fat, %	4.03±0.13	3.97±0.12
Protein, kg	100.4±4.0	101.4±3.8
Protein, %	3.20±0.04	3.30±0.04

A increased milk yield was observed in free stall pens with sand than any other bedding [20]. They also observed a low milk protein and higher pH level in milk, showed a stressful condition with mattress bedding. Increased milk fat, protein and protein percentage was observed in first lactating cows in rubber flooring than concrete [67]. A soft free stall base significantly influences the milk yield and reduces the chance of clinical mastitis and teat injury [68]. Mean milk yield and lactation length was better in the rubber flooring in comparison to the sand and concrete floor [53]. Daily lying time was increased in rubber flooring than any other type of bedding [53].

Reproductive performance

Reproductive performance of dairy animals also depends on floor type. In most of the dairy farms, reduced reproductive efficiency and culling problems has been observed due to lameness. With use of some bedding materials in free stall house, fertility was better compared to tie stall house [69]. Housing on concrete is resulted in reduced display of estrous behavior. Mounting, standing and oestrus duration reduces on concrete floor [70, 71]. Reproductive activity like duration of oestrus and number of mounts was significantly better in rubber-covered slats, pasture and straw as compared to concrete floor [72]. They also found that dirt floor is helpful for mounting activity. Similarly, housing of dairy animals in compost bedded pack resulted in reduction in calving interval, days open and higher milk production than convenient bedding housing [73]. In straw used calving pen subclinical endometritis was 10.7% lower compared to other type bedding like

paper, sawdust or sand [74].

Many researchers observed that rubber flooring is better for reproductive traits in dairy animals. Rubber flooring is better as compared to concrete for successful mounting during estrus period. In rubber floor, 2.3 mounts were observed during estrus than only 0.8 mounts in concrete floor [75]. Kara *et al.* (2015) reported that reproductive problems like repeat breeding, dystocia and retained placenta were lowest in the rubber bedding than concrete and sand bedding [Table-3] [53]. Contrary to these, finding no effect of rubber flooring in estrus behavior and other reproductive performance was also observed [57].

Table-3 Effect of bedding materials on reproductive performance of dairy animals [53]

Resting surface	Repeat breeding	Dystocia	Retained placenta
Concrete(n= 467)	121 (25.91%)	19 (4%)	29 (6.2%)
Sand (n=130)	26 (20.8%)	4 (3%)	9 (6.9%)
Rubber (n= 112)	16 (14.2%)	3 (2.6%)	2 (1.7%)

n = Number of animals.

Lameness

The lameness has a direct negative effect on profitability of a dairy farm [76], 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 has 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 [77]. Hard floor results in lameness problem and causes white line damage and horn lesion. In dairy animals, slipping problem was higher in concrete with fully slatted floor than perforated floor and perforated floor with rubber mattress [78]. Similarly, sole hemorrhages problem is less in the rubber flooring and highest in concrete [64, 79]. Claw injuries directly impact negatively on the reproduction and production of the animals [80]. A dairy animal reduces milk production due to sole ulcer. Lame cows had reduced in 1st service conception rate and pregnancy rate, increased ovarian cysts [81]. So these result showed a reduction in reproductive efficiency due to lameness [82]. In dairy farm, huge economic loss occurs due to higher rate of culling and fertility problems. Laying behavior of dairy cows is highly affected by lameness [83]. A lying time reduces 5 hours per day due to foot lesion scores [84]. In other observation it was found that lying time was not affected by the lameness however mean bout duration time was longer in lame cow (89.3 ± 3.89 min) than non lame cow (80.7 ± 3.90 min) [85]. During the transition period, lame cows had longer lying time with more number of lying bouts than non-lame cows, which is due to pain in limbs [86].

In deep bedding, prevalence of hock injury is very less [87]. In a study of 34 dairy farm, it was found that prevalence of lameness and hock lesion (14.4% and 49.4%) was lower in deep bedded free stalls and higher in mattress (19.8% and 67.3%) [88]. The prevalence of lameness was higher in mattresses (27.9%) than deep sand (17.1%) [89]. No considerable differences were observed in the incidence of clinical lameness between the group housed on rubber or the concrete [90]. Contrary to this, it was found that rubber flooring is better than the concrete [91]. It was observed that sole hemorrhage and swelling on legs was highest in concrete flooring. Slatted rubber mats bedding improves the welfare of animals as compare to fully slatted concrete and solid rubber mat [92]. They found less incidence joint swelling with slatted rubber mat than concrete and solid rubber mat (Solid; 60% of pen floor). Hock injury may also result in increased somatic cell counts and low milk production. It was observed that lameness and hock lesion prevalence was lowest in compost bedded barns (4.4% and 3.8%) than cross ventilated free stall (13.1 and 31.2%) barns and natural ventilated free stall barns (15.9% and 23.9%) [93]. Hock injury prevalence is higher with the use of sawdust for bedding and a 10 cm. deep bedding material is enough to reduce the chance of hock injury [94]. In a study of the effect of bedding materials on the behavior of lame cows and it was found that sand is more comfortable for lying down than

rubber mats [95]. Sand reduces lameness by 42% and significantly confirmed less environmental mastitis pathogens [96]. It was found that hock lesion prevalence was 29% for deep beds and 71% for mattresses. Sand bedding may reduce the development of new cases of lameness [29]. Deep sand bedding facilitates the rising and lying movements of dairy cows [97]. Lameness and swelling problems were lower with deep bedding, mat or mattresses than concrete flooring [98].

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. Sand bedding is also comfortable bedding for dairy animals. It contains lowest microbial contamination due to its inorganic nature. It results in lower SSC and it is helpful to reduce the productive and reproductive problems. In many experiments, rubber flooring is also better for reproductive performance and mounting behavior. The effects of lameness are negative for the profitability of a dairy farm. In sand bedding, lameness problems is also very less as it provides more cushion, support and traction. So, we can say that sand bedding is gold standard for bedding for dairy animals. 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.

Conflict of Interest: None declared

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