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Factors determining the choice of bedding for freestall housing system in dairy cows farming - A review

Фактори определящи избора на постеля при свободно-боксово отглеждане на крави за мляко - Обзор

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ABSTRACT

The subject of the study are the most commonly used bedding materials in freestall housing system in dairy cattle farming and the factors determining their choice. In recent years, in many countries as well as in Bulgaria there has been a tendency to change from small dairy cattle farms to larger ones by applying intensive farming systems. Many factors must be taken into account when developing appropriate interior design of dairy freestall barns. Among these factors is the providing of comfortable resting places with minimal risk of body injuries and bacterial infections. The bedding must meet many conditions: to be inexpensive, dry, not to support bacterial growth, not to contain pathogens, to be comfortable for cows to rest, and to be compatible with the manure cleaning system. Increased amounts of bedding have been shown to increase cow comfort by increasing the lying time, however controlling bacterial counts and udder health requires frequent removal of bedding material. The most widely used bedding materials in dairy cattle farming worldwide can be grouped into two main groups: organic - straw, hay (dried grass), sawdust, wood shavings, crop residues, composted manure and paper, and inorganic: sand, limestone, gypsum, rubber mats and mattresses, cement. When choosing bedding, first the comfort that it will provide to the animals must be considered, then whether the bedding will properly match the manure cleaning system and last but not least the price it will cost.

Keywords: cow comfort, cow welfare, bedding materials

РЕЗЮМЕ

Предмет на изследването са най-често използваните материали за постеля при системата за свободно боксово отглеждане в млечното говедовъдство и факторите, определящи техния избор.През последните години в редица страни, както и в България се наблюдава тенденция за промяна от малки млечни ферми към по-големи с прилагане на интензивни системи на отглеждане. Много фактори трябва да бъдат взети под внимание при разработването на подходящ вътрешен дизайн на сградите за свободно боксово отглеждане. Сред тези фактори е осигуряването на удобни места за почивка, с минимален риск за телесни увреждания и бактериални инфекции. Постелята трябва да отговаря на много условия: да е евтина, суха, да не подпомага бактериалния растеж, да не съдържа патогенни микроорганизми, да е удобна за почивка на кравите и да е съвместима със системата за почистване на сградите. Доказано е, че увеличените количества постеля увеличават комфорта на кравата чрез времето за лежане, обаче контролирането на броя на бактериите и здравето на вимето изискват често

отстраняване на материала за постеля. Най-широко използваните в света материали за постеля в млечното говедовъдство могат да се групират в две основни групи: органични: слама, сено (изсушена трева), дървени стърготини, талаш, остатъци от растителни култури, компостиран тор, хартия. Неорганични: пясък, варовик, гипс, гумени постелки и матраци, цимент. При избор на постеля, първо трябва да се има предвид комфортът, който тя ще осигури на животните, след това дали ще съответства правилно на системата за почистване на оборския тор и не на последно място цената, която ще струва.

Ключови думи: endofitske bakterije, soja (*Glycine max* L.), sekvenciranje 16S rRNA gena, fenotipska karakterizacija

INTRODUCTION

The subject of the study are the most commonly used bedding materials in freestall housing system in dairy cattle farming and the factors determining their choice. The market demand for milk and dairy products is determined by consumers' desire for cheap, safe, high-quality food produced through socially responsible managerial practices (Fulwider et al., 2008). In recent years, in many countries as well as in Bulgaria there has been a tendency to change from small dairy farms to larger ones with the use of intensive farming systems (Gergovska et al., 2013). Many factors need to be taken into account when developing a suitable interior design for free stalls housing buildings. One of the factors influencing cows' productivity and health is the provision of adequate housing conditions free of stress and clean environment. Among these factors is the provision of comfortable resting areas with minimal risk of injuries and bacterial infections (Boone, 2009). Rest is an important activity for cattle, in particular for dairy cows, which is more than 50% of their daily activities (Haley et al., 2001; Greenough, 2007). Drissler et al. (2005) found that cows that lay 12 to 14 hours a day had higher productivity and showed no signs of physiological stress compared to those who lay shorter (Tucker et al., 2007). Longer time spent lying down prolongs the rumination time, increases blood flow to the mammary gland, and lowers tension on the hoof (Rao et al., 2014). Cows tend to lie down, and if for some reason they are obstructed, they subsequently compensate the lying time at the expense of other activities, such as reducing social contact time, faster feeding, and more. (Munksgaard et al., 2005). The time the cow spends lying down has been used in a number of studies as a measure of the comfort the resting area provides. The type of bedding used in loose-housing of dairy cows has a considerable effect on the animal comfort provided by the stalls (Van Gastelen et al., 2011; Dimov et al., 2015).

The effect of the lying surface is expressed in several aspects, which include the dairy cows behavior, their legs health status and in particular the hoof and udder, and as a consequence their milk productivity (Tucker et al., 2009). The presence of contaminated and wet stall bedding results in a higher percentage of mastitis caused by pathogenic micro-organisms from the environment (Gergovska et al., 2012; Miteva et al., 2012a), as well as additional costs of extra labor during milking and lower milk quality (Carlsson, 1999). For the udder health of the cows that spend most of the day resting, it is essential that the bedding is soft, dry and clean. There is a close relationship between the microbial density of the teats and the material used for bedding. Polluted udder and tits are thought to be the main sources of environmental bacteria causing intramammary infections (Diler, 2019).

Studies in a large number of farms show that the lack of bedding in stalls in lose-housing reduces the longevity of the cows. There is sufficient data in the literature that indicates an increase in a number of the hoof diseases and lameness when there's absence of bedding (Rushen et al., 2008). According to Drissler et al. (2005), when the amount of bedding used is insufficient, the rate of hock injuries increases and the cows refuse to rest in such stalls (Bernard, 2004). The use of large amounts of litter has been shown to improve cow comfort, reduce lameness, hock lesions and increases the cow lifespan (Tucker and Weary, 2004). Inappropriate types of bedding force cows to constantly change their positions. Thus, the number of rest periods increases while the total rest time decreases (Mogensen et al., 1997).

Requirements for bedding

According to Fregonesi et al. (2007) the soft, dry and with consistent quality and quantity bedding resembles the best floor characteristics, such the animals have on pasture. According to the authors, the bedding should provide thermal comfort, cosiness and to allow the cows to lay down and get up without the risk of slipping. In addition, bedding should help keep animals clean with minimal labor (Chaplin et al., 2000).

One of the factors for the resting place comfort is the thickness of the bedding.

Boone (2009) summarizes that the thickness and adhesion of the bedding materials are converted into new emphasis at dairy farms in relation to cow health and behavior. The amount of bedding used on the stall surface is a major problem for farmers because it causes problems when trying to increase both the comfort and cleanliness of the cow. It has been proven that increased amounts of bedding increases cow comfort through lying time, however, controlling the bacteria number and udder health require frequent removal of bedding material. The accumulation of bedding can lead to a large number of potential pathogens for udder. Recently, researches have begun to focus on different bedding materials and how they benefit both farmers and cows. As Boone (2009) points out, methods for determining bedding thickness are quite subjective at this time.

Another problem with bedding materials is maintaining the desired quantity and good quality. According to Gaworski et al. (2003) the amount of bedding in individual stalls often changes. The cows, coming out the freestalls, scatter part of the bedding along the manure alley, and another part is removed by the staff when cleaning the stall from the feces that have fallen on the bedding. As a result, the amount of bedding inside the stalls decreases over time, and if no new bedding is added for a long time, the cow's comfort will deteriorate, various injuries may occur, and even the animals may refuse to use the stalls. Indicative of the bedding quality is the presence or absence of abrasions on the hock joints. In the studies of Tucker et al. (2004) in British Columbia were found less hock joint abrasions when using a sufficient amount of bedding on rubberized mattresses.

Tucker et al. (2009) found that adding extra bedding on the stall floor improves cow comfort measured as lying time. The duration of lying is a good indicator of the comfort and bedding quality.

The adhesion or abrasiveness of the bedding material affects the use of the bed surface associated with the moves of the cow when lying down and getting up, as well as the possibility of injury to the hocks and knees. There are no studies to determine the mechanical properties of bedding materials. However, studies comparing the effects of different bedding materials on hock joints injuries of dairy cows can be used to estimate the abrasiveness of bedding material (Boone, 2009).

Bedding must meet many other requirements: to be cheap, dry, not to support bacterial growth and to contain no pathogens, to be comfortable for cows to rest and to be compatible with the building cleaning system (Bey et al. , 2002), but in most cases, farmers choose and justify their choice of bedding with the economic feasibility, the physical comfort that it will provide and how well it will maintain the udder health and cleanliness. However, very few farmers take into account the thermal comfort that bedding must provide. Although farmers are aware of the importance of bedding, the costs associated with high quality bedding materials compel them to use less bedding or look for alternatives such as dried grass (van Weyenberg et al., 2015).

Temperature effect of bedding materials

Boone (2009) points out, that cows are homeotherms, so they must maintain their body temperature within the heat-neutral zone. In cold climates, cows usually eat more to increase their heat production as well as huddle with others or lie down. In warmer climates, the cow must produce as little heat as possible and must release as much heat as possible into the environment. The bedding ability to eradiate or absorb heat can affect the decision of whether cows lie or stand in stall. Temperature can affect the use of the stall, affecting the thermal comfort of the beds.

The ambient temperature within the free space in buildings affects the behavior of cows. Thoreson et al. (2006) found in experiment during summer that sand (60.8% occupancy) was preferred over mattresses (occupancy from 19.4 to 32.5%) and rubber mats (occupancy 12.3%). During the winter sand bed stalls (occupancy 27%) were used less compared to the summer months (occupancy 60.8%). Dimov et al. (2017) report that, regardless of the bedding material used, the stall bed surface reaches higher values of surface temperature than the concrete surface of the manure alley. Dairy cows prefer to lie on a cooler surface, which helps them by conductive heat exchange to lower their body temperature. An increase in the floor surface temperature above 20 ° C leads to a considerable decrease in cows preferring to lie in stalls and, accordingly, to lower values of the cow comfort index and the stall usage index.

According to House and Eng (2016), bedding should also meet the following characteristics: bedding material that is too soft can deteriorate quickly and can retain moisture from leaked milk or manure in the layer under the cow when lying down. Bedding that is very solid can be uncomfortable and slippery. The base must be safe enough and grooved to ensure a good grip on the cow when standing up and lying down. The main material must be durable without being abrasive for legs and hooves of cows. The most widely used bedding materials in dairy cattle farming in the world can be grouped into two main groups (Kumar Singh, 2018):

Organic: straw, hay (dried grass), sawdust, wood shavings, crop residues, composted manure, paper.

Inorganic: sand, limestone, gypsum, rubber mats and mattresses, cement.

Each of these two groups of bedding materials has its advantages and disadvantages (Kumar Singh, 2018). Organic bedding materials absorb moisture well, they are compatible with the manure processing systems, easily accessible, available in sufficient quantities in different regions of the world, and are not expensive. In contrast, they are a reservoir of bacterial populations, maintaining rapid bacterial growth, which increases the risk of mastitis. Inorganic bedding materials are inert in nature and do not support bacterial growth but they are not readily available in different regions and compatible with the manure processing systems.

Kour (2017) points out, that different types of bedding materials can be selected, taking into account the animals comfort and the economic status of the farmer. Because the cows are large animals, the amounts of bedding providing adequate surface for lying are also large. In addition to the comfort and health of the cows, it should be inexpensive and with a labor low cost.

Sawdust and wood shavings

Wood shavings and sawdust are often used as bedding for dairy cows. They have the advantage over the inorganic materials being decomposed by microorganisms in the manure processing system, but they allow the growth of microorganisms (pathogens). According to Kour, (2017) sawdust can be a very good bedding material when properly managed. Unsifted sawdust is inappropriate because it may contain pieces of wood and even nails. Wet shavings are an excellent environment for the development of many pathogens, so it is essential that they are stored dry. Allen (2007) recommends that when using sawdust for bedding, they first should be dried in furnace, thus in the drying process, are destroyed most microorganisms. The amount of bedding the author recommends is 3 kg of sawdust per cow per day. The quality of bedding from woodworking waste depends a lot on the type of wood. Bey et al. (2002) find that sawdust from pine and cedar contain acidic substances, fats, turpentine and phenols, which have an adverse effect on bacterial growth compared to sawdust from oak and other deciduous species.

Muller and Botha (1997) find that the use of deep sawdust bedding increases the time spent by cows lying and reduces the standing time. In a study, Schütz and Cox (2014) find that sawdust is preferred over rubber mats from cows and also they are cleaner too.

The advantages of wooden sawdust as bedding are: maintain higher hygiene in dairy cows (Schütz and Cox,

2014); the amount of ammonia released is less, especially when using sawdust from conifers (Misselbrook and Powell, 2005).

Disadvantages of wooden sawdust as bedding are: raising the cost to purchase and their more difficult finding (Cook et al., 2004); after moistening provide a good environment for microorganisms causing various diseases, some sawdust (cherry, walnut, cedar) cause laminitis (Janni et al., 2006).

Compost

In various European countries, the use of composted bedding materials has become more and more popular in recent years because of the possibility of combining them with slatted floors (van Gastelen et al., 2011). "Box" compost is a new bedding material consisting of composted biodegradable household waste. The material is heated to 70 °C for 3 days, thereby reducing the bacterial count and killing the weed seeds, and then bacteria from Lactobacillus species are added to the mixture to compete with potentially pathogenic microorganisms (Groot Antink, 2009). Endres and Barberg (2007) consider that the composted material is promising as a material for bedding, but after drying. However, other authors point out that, despite the low content of microorganisms in the dried compost mass, its use for bedding is questionable, since, after laying it on the beds of cows, it rapidly increases its humidity and the number of microorganisms increases very rapidly (Britten, 1994).

Similar to the sand, the compost moves with the animal and provide comfortable surface for laying and standing.

Cows with a compost bedding show reduced incidence of lameness as compared to cows housed in freestall barns with a sand bedding (Lobeck et al., 2011). Well-managed freestall production systems farms with a bedding of compost and sand do not differ significantly in terms of hock joint health, locomotion and cows hygiene. Also, no significant differences were observed for SCC in milk and incidence of clinical mastitis between the two bedding materials (Eckelkamp et al., 2016).

The advantages of compost as bedding are: reduces the incidence of the hock joint lesions in cows (van Gastelen et al., 2011).

Disadvantages of compost as bedding are: the emissions of ammonia that are released are higher for this type of bedding (Misselbrook and Powell, 2005).

Straw

Chopped straw is a widely used material for cow bedding and when used in clean, dry, well stored straw and managed properly, it can provide a comfortable environment for cows (Kour, 2017). However, when straw bedding becomes heavily contaminated, especially in deep stalls, there is a risk that it will become a suitable environment for pathogens responsible for causing infectious problems for foot and udder.

According to Tuyttens (2005) straw is the best bedding for cows in terms of comfort and keeps cows clean and dry. Other advantage of straw is that it provides a better thermal comfort, which is important, when cows are housed under more severe winter conditions. On the other side, straw is favorable environment for development of various pathogenic bacteria. Miteva et al. (2012a) report that in the process of using straw as bedding, there is a significant increase in coliforms and staphylococci, while the number of streptococci does not change. The authors examined bacterial growth in the bedding of rice husks, finding a significant increase in coliforms and staphylococci, while the number of streptococci increased slightly.

A study by Wechsler et al. (2000) showed that using straw as a bedding in individual stalls revealed fewer soft-tissue injuries and a lower rate of bald areas to the hock joints, than in cows housed with rubber-mats. Penev et al. (2019) report the lowest percentage of hock lesions in dairy cows in a loose housing production system using straw for bedding. The highest percentage of hock lesions is observed when using rubber mats, with the addition of a certain amount of straw on the rubber mats, the percentage of hock lesions is significantly reduced.

Dimov et al. (2015) found that in freestall production system the use of straw mixed with composted manure in 1:1 ratio provides better cow comfort compared to the rubber mats. Allen (2007) recommends that the amount of straw should be 5 kg per day.

The advantages of straw as bedding are: when straw is used for bedding less lesions, scabs formations and injuries to the hock joints of dairy cows are registered (Wechsler et al., 2000).

Disadvantages of the straw as bedding are: the need for more intensive management and higher cost, due to the more frequent bedding addition as a result of scattering from the cows (Benson, 2012); after humidification, straw is a very good environment for development of microorganisms, causative agents of mastitis and other diseases (Nordlund and Cook, 2003).

Rubber mats and mattresses

The housing of dairy cows only on a concrete floor is one of the main causes of lameness occurrence and deterioration of their comfort in general (Vanegas et al, 2006), though the concrete flooring is more durable, affordable, and easy to clean. In studies of Telezhenko et al. (2009) is reported that when they have a choice, cows prefer to move and stand on a floor covered with rubber flooring instead of directly on concrete. Adding rubber mats on the concrete base of stall improves comfort and contributes to proper locomotion of cows (Schütz and Cox, 2014). The use of rubber mats contributes to the health of the dairy cows' hooves and reduces the percentage of lameness in the herd (Rushen et al., 2007).

One of the latest bedding innovations is geotextile mats. They are manufactured from a variety of commercially available materials. They can be used in both tied and freestall housing. They have waterproof outer surfaces and are filled with a variety of materials, including rubber crumbs, polyethylene foam or water (Endres, 2012). They are marketed as a product that requires no bedding, but studies show that added bedding makes them much more attractive to cows.

Another innovation is the stall mats for cows. They are usually constructed of rubber with a thickness of 1.9 to 2.5 cm, or from a multi-layer vinyl. Due to their firm nature, they offer the least improvement in cow comfort on the concrete base. However, they provide a non-abrasive, non-slip surface that is impervious to water, bacteria and mold, providing traction for the cow's hooves with the flooring while offering low maintenance requirements without adding bedding. Stall mats, properly mounted on a sloping surface, facilitate fluid flow, keeping the cows drier. In addition, the stall mats offers a layer of insulation between the cold concrete base and the cow at low temperatures in winter (Kour, 2017).

Cow mattresses consist of an outer sheath made either of synthetic materials or of rubber filled with an inner core of crushed rubber, gel or water. In addition to the advantages of the solid geotextile mats described above, mattresses are usually much thicker than the mats, moreover, they offer additional cow comfort. Mattresses filled with crushed rubber often become stiffer over time due to particle compaction in the core. To overcome the compaction formation gel mats are developed, where the core is composed of multitude of compartments filled with a gel substance, instead of crumbled rubber. These mattresses are designed to stay softer for much longer periods and to reduce the pressure points on the contact points of the cow with the mattress.

Dimov et al. (2017) report that, the highest stall surface temperature values during all seasons are reached when rubber mats were used compared to rubber mats and straw, and compost and straw. There the biggest difference between the minimum and maximum surface temperatures is reported. Slightest is the variation in minimum maximum surface temperatures of the stalls when bedding of compost and straw is used.

In a study of Weary and Taszkun (2000), the relationship between hock joint injuries and the stall surface is reported. The cows are evaluated on a base of severity of hock joint injuries in 20 farms where sand, sawdust and rubber mattresses were used as bedding. When using a rubber mattresses hock abrasions and

wounds in 91% of the cows are reported versus 24% for those with sand stall bedding.

Miteva et al. (2012b) find that the use of rubber mats provides better comfort than using straw as bedding on a concrete floor. The results obtained show that the use of insufficient amount of straw for bedding on the concrete base of the stall does not contribute to improvement of the cow comfort.

On the other hand, the use of rubber mats has also and a negative impact. A number of studies indicate that the percentage of cows with injuries is higher on farms using rubber mattresses than farms using stalls with deep sand bedding (Rushen et al., 2008). The use of rubber mats and mattresses is widespread in the central and northern regions of Europe, but has recently been increasingly used in areas of the Mediterranean basin, characterized by a completely different climate.

Another problem is reported when rubber mattresses are used - these mattresses are filled with rubber or foam and, when are used for several years, are compressed and solidified. Thus, they lose considerably their softness and do not provide adequate comfort.

Recently, there is experimenting with the creation of such mattresses, but instead of rubber or foam they are filled with a gel - like substance. It is found that the time cows spend lying on these mattresses is increased by 3.8% compared to regular ones. This is a relatively new product and researches are still insufficient to state how they affect the comfort of dairy cows (Main, 2013).

Chaplin et al. (2000) report a relationship between hygiene of udder and rear legs, and the bedding type on the stall base. The author conclude, that cows have better hygiene indicators when the stall base is covered with rubber mats compared to those covered with mattresses. Herlin et al. (1997) find that when cows are given the choice between soft rubber mattresses, standard rubber mattresses and concrete, 71% of cows prefer to lie on soft rubber mattresses, 55% on standard rubber mattresses and only about 18% on concrete.

To improve the cow welfare and hygiene, according to De Palo et al. (2006), both the quality of the bedding materials used and the climatic characteristics of the microhabitats must be evaluated. The materials used as bedding in stalls change their properties according to the microclimatic conditions in which they are used. The percentage of standing with all four feet in boxing is higher in the summer than in the spring (13.6 versus 8.1%), although the same rubber mats or mattresses are used (Lombard et al., 2010). In Finland, Manninen et al. (2002) found that in winter cows prefer bedding (straw and rubberized bedding), providing them with better thermal comfort than sand bedding. The same authors found no difference in preferences during the summer season.

Kristula et al., (2008) reported a trend, showing that the number of bacteria on the mattress increases over time and is the highest at 36 and 48 h, suggesting that daily cleaning and adding of will improve bacteria control on dairy cow mattresses. The cows would be exposed to fewer bacteria for a longer period when new bedding is added daily.

The use of rubber mats in dairy cow freestalls, without adding bedding on them leads to an unwanted increase of the surface temperature, which in turn leads to reluctance of the animals to use stalls.

Both the rubberized surface and the compost obviously do not provide an opportunity to cool the surface of the body during lying and cows prefer to stand upright at higher ambient temperatures (including of the air and stall surface) (Dimov et al., 2017).

The advantages of rubber mats and mattresses are: when they are used animals have less problems with hooves (Leonard et al., 1994); the initial cost of purchase are high, but maintenance and labor costs are considerably less subsequently (Bernard, 2004).

The disadvantages of rubber mats and mattresses are: after several years of use they are compressed, harden and lose their softness (Main, 2013); more often occurrence of injuries to the animal's legs is observed

(Wechsler et al., 2000); with the time and after wetting, their surface becomes very slippery, which is a danger for cows (Boone, 2009).

Water beds

Dual chamber mattresses full of water, often called "water beds" for cows, have become popular in recent years due to the low incidence of hock damage, the minimal bedding requirements and the long life of the mattress (Kour, 2017). The dual chamber water beds are constructed of a system of rubber chambers with water. They are made using several layers of rubber for durability and two layers of nylon tape. The dual chamber system divides the bed into two pillows. The smaller pillow is designed for the cow's knees and the larger pillow is for the cow's body. The back edge of the bed is inclined at a 35 ˚degree angle, which makes a smooth transition from the surface of the water bed to the surrounding space (Simkova et al. 2013). According to Geist (2019), dual chamber beds offer additional support for the cow's knees. Once the cow is kneeled, the pillows offer softness at pressure points, provide better stability and prevent leg and hoof injuries that can reduce mobility.

Maintaining a constant temperature is their greatest advantage. In countries with hot climates, the water beds maintain a cooler surface of the stall and at low temperatures provide good insulation and do not freeze.

During the coldest months in the study of Fulwider and Palmer, (2004) in Wisconsin, comparing 13 different stall surfaces, water beds were the most preferred basis for resting of cows. When comparing the occupancy of the stalls, the water beds had the highest occupancy at all temperature ranges. During the coldest times of the year, waterbeds are preferred because of their ability to retain and store heat. A study by Simkova et al. (2013) indicated that cows that preferred water beds were calmer, cleaner, and milk yield increased throughout the entire study period. Dual chamber water beds reduce the incidence of leg diseases, in particular the appearance of hock joints wounds due to pressure (Fulwider et al., 2007). At the same time, according to the study, the share of culled cows was lower when using dual chamber waterbeds.

Dual chamber waterbeds allow milk or urine to drain from the pillows as they have a rounded shape. This technology keeps the animals clean and drastically reduces the risk of infection. More dairy cows are cleaner and less suffering from mastitis (Ward et al., 2002).

Wadsworth, (2014) found that lying time was longer for cows housed on dual chamber cow waterbeds (10:32 ± 0:13) when compared with cows housed on conventional rubber mattresses (9:47 ± 0:15).

According to Geist (2019), water beds cost about one-third more than rubber mats, but they get damaged over time and are used shorter.

The advantages of water beds are: injuries and abrasions of the dairy cow legs are not registering, animals are cleaner and a lower incidence of inflammatory processes of udder – mastitis is reported (Simkova et al., 2013); their use period is longer than other types of mattresses (Fulwider et al., 2007).

The disadvantages of water beds are: they require a longer habituation period of the cows to this type of beds because of their fluctuating surface (Fulwider and Palmer, 2004).

Sand

In countries with a suitable climate, a big part of farmers value the sand as the most suitable for stall bedding. According to them, it contributes to good udder and hoof health, high animal hygiene, it has a low cost, and provides a comfortable resting place for cows (Norring et al., 2008). Cook (2009) found that cows prefer sand bedding as compared with the rubber mats, which leads to increasing the length of the lying time up to 12 hours a day.

According to the author, this is due to the fact that the sand provides better traction and facilitates the moves of cows when lying down and getting up in the stalls. The sand generally does not contain carbon or nitrogen required for growth of microorganisms. It also has a type of texture that allows the cows to move it around and to provide a good base for lying. Compared to other bedding materials, most studies have shown that cows

prefer the sand. When cows have a choice between sand and rubber mattresses in places with cooler climates, preferences to the sand are decreasing (Thoreson et al., 2006). The disadvantage of sand as a litter is that the manure cleaning system must comply with it. There are systems that can separate the sand from the manure and reuse that recycled sand, but this must be done provided that the organic material contained in it is not more than 3% in order not to become a good environment for development of microorganisms, in addition, this increases the cost of production (Bernard, 2004). The particle size of the sand should be 0.1-1 mm and to be with equal size (Schoonmaker, 1999). This is essential not only for comfort but also for the moisture content of the sand (Stowell and Inglis, 2000). The uniform particle size allows proper drainage of urine or moisture, which prevents bacteria from growing. Good drainage also prevents forming of bacterial colonies on the surface of the beds, which is responsible for the exposure of the tits when the cow lies (Zdanowicz et al., 2004) and is a risk factor for mastitis from the environment. Sand is also non-absorbent, which means that it does not retain or absorb urine, leaking milk or other liquids (Gooch and Inglis, 2010), compared to other bedding (eg straw, sawdust, etc.).

The depth and height of the bedding are also an important factor for the comfort of dairy cows. Cook (2010) assumes a minimum of 25 cm depth of sand bedding. Very small or large sand particles can cause discomfort to the animals. Abnormal size can lead to wounds on the legs or to sticking on the tits top. The bacterial count and moisture content are lowest in the surface 25 mm sand layer (Hogan et al. 2012).

In stalls, the sand provides traction that allows the cows to stand up without slipping, which also increases the duration of use of the stall for lying (Bell, 2007). Cows can also get a good feeling from the way the sand embeds their legs when they get up or lie down. This can also reduce their propensity to move back and forth to take a comfortable position to stand up, reducing the associated with that knee and hock injuries (Bickert, 1999). The sand scattered around the yard, in alleys, etc., gives cows extra traction while moving, so they exhibit less fear of slipping, resulting in less compromised cow traffic. Sand also provides the cow with enough traction to exhibit natural behaviors, such as mounting other cows and estrus manifestation, which they may refuse to show on a slippery surface (Anderson, 2008).

Overton et al. (2003) and Cook et al. (2004) studying the relationship between the various comfort indices and the bedding used, conclude that the sand provides better comfort to dairy cows than rubber mattresses.

According to Buli et al. (2010) the widespread use of sand for bedding is due to the following qualities - providing animal comfort; due to its inorganic origin does not allow an increase in the number of microorganisms; reduces heat stress; provides better traction on animal hooves and prevents slipping.

The sand can be extracted from various places: construction sand, dredged sand, beach sand and quarry sand (Gooch and Inglis, 2010). If, after separation from manure, the intention is to disperse the sand into the soil, it should be noted that some sources of sand may change the pH of the soil (Bell, 2007), so care must be taken when selecting suitable sand for the farm.

Bell, (2007) also expresses concern about the stability of the sand obtained from beaches and river beds. Another problem with these types of sand is that they may contain pebbles, shell pieces or other foreign bodies that can reduce the cow's comfort in the stalls (Gooch and Inglis, 2010). In addition, there is a possibility that this sand may also be contaminated with organic material (Bell, 2007). The sand from these sources must be washed and sieved before use (Rodenburg and House, 2000). The advantage of this type of fine sand is that it can stay longer and therefore requires less quantity than all types of sand, and is less abrasive for pumps and other farm machinery (Schoonmaker, 1999). Naturally produced sand has less uniform particle sizes (Stowell and Inglis, 2000) and therefore is less porous (Gooch and Inglis, 2010), as smaller particles will fill and block the gaps between larger particles, leading to worse drainage than other sands. Natural sand can therefore become more compact

and firmer than coarse sand (Schoonmaker, 1999).

The price of the sand varies and the delivery cost also contributes to this, since the sand is heavy and requires specialized transport for delivery to the farms. Buli et al., (2010) indicate that this can be a significant factor for the farms located outside the areas with accessible sand. Other price implications are the natural amortizations of agricultural machinery, which will need to be replaced more often. Steps have been taken to reduce this, ie. replacing the chains of scrapers with ropes and metal scrapers with rubber ones reduces the wear of concrete. Sand requires specialized treatment of animal manure, which is often cited as the greatest challenge (Rodenburg and House, 2000) and modifying systems can be expensive. Sand is also not suitable for calving places as it adheres to calves (Stowell and Inglis, 2000). Sand storages can freeze in cold weather; therefore, the use of sand may be limited by geography - although there are ways to overcome this, e.g. inside the storage.

The advantages of sand as bedding are: it provides better traction for animals (Cook et al., 2004); it is an unfavorable environment for the development of microorganisms that are a prerequisite for mastitis occurrence in dairy cows (Tucker and Weary, 2004); lowers the incidence of hock joint lesions in cows (van Gastelen et al., 2011); good bedding against heat stress, but not in cold, contributes cooling of the body (Buli et al., 2010); has a low water retention capacity and a loose structure that allows cows to move it about as desired (Thoreson et al., 2006); allows the use of the same sand several times after proper recycling (Bernard, 2004).

The disadvantages of sand as bedding are: it is incompatible with most manure cleaning systems, a more specific manure management is needed (Tucker and Weary, 2004), so a new manure cleaning systems is needed, which is accompanied by serious financial costs; in winter months it is not preferred by animals because it offers a cooler surface for lying (Thoreson et al., 2006).

CONCLUSION

When choosing bedding, first the comfort that it will provide to the animals must be considered, then whether the bedding will properly match the manure cleaning system and last but not least the price it will cost. It is undesirable to compromise with the above mentioned, but it is necessary to find optimal variant so that the bedding can be relatively inexpensive, compatible with manure cleaning system and provide adequate comfort of dairy cows.

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