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Effect of different free stall surfaces on behavioural, productive and metabolic parameters in dairy cows

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ABSTRACT

Two experiments were carried out on 56 lactating dairy cows in an experimental free stall barn comparing four different lying surfaces: straw bedded pack (ST), rubber mat (RM), mattress (MA) and sand (SA). In the first experiment (26 days) cows were allowed to choose between free stalls with each lying surface. The rest area was filmed for three non-consecutive days to record the total duration of lying and standing in the free stalls with each lying surface, and the duration and frequency of lying and standing bouts. In the second experiment, lasting 50 days, the cows were divided into four groups; each one was kept in a free stall pen with only one kind of lying surface. Milk yield was recorded and individual blood and milk samples were collected. Blood metabolites and milk characteristics of the samples were analyzed. During Experiment 1 the time spent lying down in the free stalls was 631 min cow^{-1} day^{-1}, and the cows spent more time lying on SA (44.1% of the total lying time) and on ST (33.2%) than on RM (11.6%) and MA (11.1%) ($P < 0.001$). The total number of lying bouts per day was greater ($P < 0.001$) on SA and ST than on RM and MA, but there were no differences in the duration of lying bouts. On average, free stalls with SA were occupied for 74.87% of the time, those with ST 60.4%, and those with RM and MA 31.41% and 31.47% respectively. The free stalls with SA and ST were mainly utilized to lie down (85.4% and 80% of the total time spent in these free stalls respectively), while those with RM and MA were mainly utilized to stand (48.4% and 46.4% of the total time spent in these free stalls respectively). Different milk yield change patterns were observed during Experiment 2, with greater values at the end of the experimental period in SA compared with RM ($P < 0.001$) and MA and ST ($P < 0.05$). In MA greater plasma ceruloplasmin (cf. RM and SA; $P < 0.05$), greater plasma globulin (cf. RM, ST and SA; $P < 0.05$) and lower plasma albumin (cf. ST; $P < 0.05$) were observed. Furthermore, in MA lower milk protein content (cf. ST and SA; $P < 0.05$), with greater pH (cf. ST and SA; $P < 0.05$) and lower titratable acidity (cf. ST; $P < 0.05$), were observed. In conclusion, our results show that cows spent lying time mainly on the softer surfaces, either sand or straw bedded pack, rather than mattress and rubber mat. It moreover seems that surface characteristics that are desirable for lying (e.g. softness) may not be the properties of surfaces most suitable for standing (e.g. stability). Finally, the results obtained with milk yield, milk characteristics and blood metabolites indicate that sand seems to be the best lying surface for dairy cows.

1. Introduction

Lying is an important behaviour for cattle, representing about 50% of their daily time (Dechamps et al., 1989; Krohn

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and Munksgaard, 1993). Recognized benefits of adequate resting time (up to 14 h/day for the most productive cows) include reduced stress on feet, reduced lameness, increased feeding activity, increased rumination activity and greater overall cow health (Grant, 2006). Furthermore, blood flow to the udder is increased during lying (Metcalf et al., 1992; Rulquin and Caudal, 1992) and when cows are deprived of lying, growth hormone in plasma is reduced with negative effects on milk production (Munksgaard and Løvendahl, 1993). Disturbed rest can also increase hypothalamo–pituitary–adrenal activity (Ladewig and Smidt, 1989) and activity of the sympathetic nervous system in cattle (Müller et al., 1989). These impact the physiological balance of dairy cows through modification of nutrient availability and utilization, increased nutritional requirement, depressed productive efficiency and modify milk characteristics (Bertoni et al., 2003). It is important to optimize their resting time in order to ensure the welfare and productivity of dairy cattle.

A high variability of resting time was observed. Dairy cattle spend approximately 8–16 h/day lying down, making the quality of the lying surface important to the animals (Dechamps et al., 1989; Haley et al., 2000, 2001). Lying surfaces for dairy cows must provide thermal comfort and softness, yet they must also be durable and have sufficient friction to allow rising and lying down without slipping. Finally, they should help in keeping cows clean and healthy whilst minimizing daily labour requirements (Nilsson, 1992; Rodenburg et al., 1994).

In free stall housing, poorly designed stalls lead to reduce stall occupancy and the type of lying surface in the stall may affect the time spent lying down. Lying time and the frequency and duration of lying bouts have been used as measures of cow comfort (Munksgaard and Simonsen, 1995; Haley et al., 2000). Previous work has shown that cows tend to spend more time lying on softer surfaces (Tucker and Weary, 2001). Lying times are lower and standing times higher when dairy cattle are forced to use hard surfaces, specifically concrete (Haley et al., 2000, 2001). Sand bedding, despite being popular in some areas, is often not preferred by the cows. Shim et al. (1998) and Tucker et al. (2000) found a preference for materials other than sand and Manninen et al. (2002) observed that cows avoided sand.

The lying surface in the stall also appears to affect leg injuries. Fewer leg injuries are reported on mattress than concrete (Haley et al., 1999), with rubber mat as an intermediate (Rodenburg et al., 1994). Cows lying on sand have fewer hock injuries than cows lying on sawdust or geotextile mattresses and have fewer injuries on deep-bedded stalls than on mattresses (Weary and Taszkun, 2000). More recently, Fulwider et al. (2007) found fewer tarsal lesions in cows on sand beds than those on rubber-filled mattresses. Nilsson (1992) found a positive relationship between lying surface penetration, or hardness, and hock injuries. Claw health may also be improved by increased amounts of bedding (Colam-Ainsworth et al., 1989). Cook et al. (2004) observed a greater prevalence of clinical lameness in cows kept in free stall barns using mattress rather than sand, associated with more time spent standing. Clinical and subclinical lameness and leg injuries, but also trauma, gastro-intestinal endotoxins and mastitis, cause an inflammatory response (Grimble, 1990), with alteration of blood parameters, reduced feed intake and modified prioritization of nutrient use (Elsasser et al., 2000), with variable consequences on milk yield and composition (Bertoni et al., 2003);

Lying surfaces may also influence udder health. Organic bedding, like sawdust, had higher bacteria counts than non-organic bedding such as sand (Hogan et al., 1989), and these higher counts lead to higher counts on teats ends (Bishop et al., 1981; Hogan and Smith, 1997). More recently, De Palo et al. (2006) observed that organic bedding did not increase the coliform load on the lying surfaces. Although it is evident that high bacteria counts on teat ends are related to udder infection, there is only limited evidence that higher counts in bedding increase the risk of udder infection (Hogan et al., 1989).

Our aim was to assess the effect of different free stall surfaces (rubber mat, mattress, straw bedded pack and deep-bedded sand) on the behavioural, metabolic and productive response of dairy cows.

2. Materials and methods

The trial was carried out in an experimental barn (two-row free stall barn) hosting 100 Italian Friesian lactating dairy cows. The two-row free stall barn with inside feed drive way was partially open. The largest side (exposed to the west) was completely open to an unshaded paddock, while the other was half closed by a masonry wall. The face to face free stalls were 120 cm wide and 255 cm long, with neck rail (110 cm above free stall surface) and brisket board (180 cm from the free stall curb) (Fig. 1). The free stalls were designed to allow space sharing and provide forward lunging space for rising. A type of straw bedded pack was used as lying surface. It was made of a mixture of straw and animal straw waste, which was soft and not slippery, unlike loose straw. Floors in the feeding area were solid concrete and automatic scrapers were used. The rearing animals and the dry cows were kept in different barns, both with straw bedded pack as rest area. The

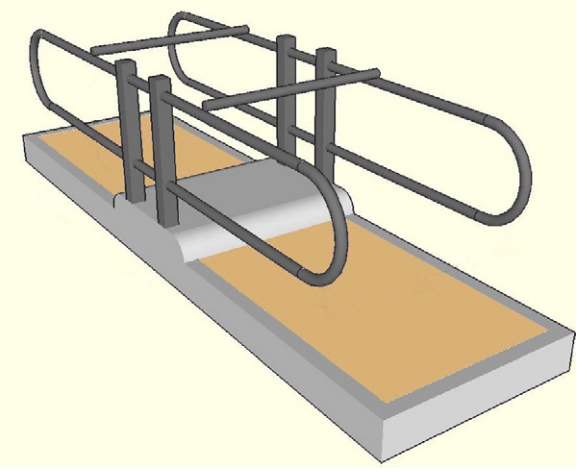

Fig. 1. Layout of the free stall in the experimental barn.