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Comparison of Lying Area Surfaces for Dairy Cows by Preference, Hygiene and Lying Down Behaviour

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Abstract. Three surfaces, concrete floor, conventional rubber matting (Kreiburg™) and Comfort mat™ (a soft rubber mat) were compared for their suitability for use in the lying area of cubicles and tie-stalls for dairy cows using preference, behaviour (lying down and getting up) and hygiene studies. A standard amount of bedding was given. In the preference study, 18 cows in cubicle housing had access to 18 cubicles, six of each type of floor surface. Lying down and getting up behaviour was studied using 15 cows in tie stalls and a procedure using an incomplete block design model was followed. The hygiene was evaluated in cubicle housing (16 cows and 16 cubicles) for two week periods for each surface. The cows preferred the Comfort mats™ in comparison to the rubber mats and concrete floors. In cubicles, the cows spent 71% of the observation time lying in the cubicles with Comfort mats™, 55% in cubicles with rubber mats, and 18% in those with concrete flooring. The preparation time for lying down was significantly shorter on the Comfort mats™ than on the rubber mats ($p < 0.05$) or on the concrete flooring ($p < 0.01$). The process of lying down was interrupted twice on the concrete and the rubber mats, respectively, and getting up was abnormal once on the concrete surface. More of the concrete surfaced cubicles were dung covered than were the other surfaces ($p < 0.05$). No differences in the amount of milk leakage in the cubicles were observed between the different surfaces in the morning, but in the afternoon, less milk leakage was seen on the Comfort mats™ than on the other surfaces ($p < 0.05$). In the morning, more of the cubicles with Comfort mats™ appeared to have bedding with dispersed dirt than the other cubicles ($p < 0.05$). In the afternoon, the cubicles with rubber mats appeared to be the cleanest ($p < 0.05$). The Comfort mats™ appeared to provide a very attractive surface for the dairy cows, especially since the lying down process appeared to be facilitated. To some extent, hygiene in the cubicles with the Comfort mats™ seemed to be improved, but it was observed that faeces tended to stick to the uneven surface layer.

Key words: Dairy cows, behaviour, hygiene, lying area, concrete floors, rubber mats.

INTRODUCTION

Interest in improving the comfort and hygiene of the lying area for dairy cows is increasing, in order to increase the welfare of these animals and reduce behavioural and health problems. Poorly designed tie stalls or cubicles together with a hard lying surface, will probably negatively affect the health and welfare of the cows. Cattle have a nearly constant daily need for lying, spending approximately 50–60% of the day lying down. Deprivation of lying for five to seven hours will be immediately compensated for in the following hours (Metz, 1985; Munksgaard & Simonsen, 1996). The amount of stereotypic behaviour performed by the cattle during the period of deprivation will often be elevated (Munksgaard & Simonsen, 1996). Previous research (Wander & Fricke, 1974; Nilsson, 1988) has shown that cows prefer a soft lying area made of saw dust bedding material rather than one made of other materials. In a preference test carried out by Magnusson & Michanek (1991), it was shown that the dominant animals will displace lower ranking animals to obtain a softer lying area. This occurred where there was common rubber matting, but not when bare concrete surfaces were used. However, many cows in production are still exposed to concrete lying area surfaces and minimal bedding. Using rubber mats may improve the situation, but these mats tend to be rather hard. Nilsson (1988) found that the forces of deformation when pressing a standard steel ball onto the material would exceed 1 500–2 000 N, without being able to penetrate more than 2–10 mm into a variety of rubber mats. When rising, the vertical force applied on the fore knees of the cow has been found to be about 40% of the live weight (Sato & Hasegava, 1993) which is about the same force in the steel ball test by Nilsson (1988). The

possibility of using softer material for the lying area surfaces has gained much interest during the past few years. Here, mattresses of artificial fabric filled with straw or rubber chopping, or mats being much softer than before have been introduced. In the latter category, the "Comfort mat™" has attracted increasing interest.

Improving hygiene of the lying area and to keep the udder dry and clean for 24 hours a day is major goal in order to reduce the occurrence of environmental mastitis (Johnson, 1992). The frequency of dirty cubicles will also affect the work load for the herdsman, as they have to both clean more cubicles and udders. The presence of dispersed dirt in the bedding material may be a cause for the contamination of teats and milk with dirt (Herlin & Christiansson, 1994).

The aim of the present study was to compare three different lying area surfaces, namely concrete floors, hard rubber mats (conventional) and soft rubber mats (Comfort mat™) using behavioural and hygienic parameters.

MATERIAL AND METHODS

Experimental design

The comparison of the three lying area surfaces was performed at the Animal Research Station of the Department of Agricultural Biosystems and Technology, Swedish University of Agricultural Sciences, Alnarp, Sweden. The surfaces studied were concrete floor, conventional hard rubber mats (15 mm, Kreiburg™), and soft rubber mats (Comfort mat™, 21 mm, Alfa-Laval Agri, Tumba Sweden). According to the manufacturer, the Comfort mats™ have a softness of 35–45 on a scale from 0 (water) to 100 (steel). The softness of hard rubber mats is stated to be 65–85 on the same scale. Evaluation of the lying surfaces was carried out using studies of preference, hygiene and behaviour (lying down and getting up). The preference and hygiene studies were carried out in cubicle housing and behavioural studies in a house with tie-stalls. The studies were carried out in the sequence: preference test, hygiene test and the behavioural study.

In the cubicle housing, the cubicles were of the classic type, 2.20 × 1.20 m, with a diagonal wood partition (Fig. 1). The cubicles were scraped down and bedding levelled twice daily while the cows were milked, and new bedding (2–3 kg per cubicle) provided twice weekly. The tie-stalls were 1.80 × 1.30 m (Fig. 1), and new bedding was provided twice daily (about 1–2 kg per day). A group of initially 18 lactating Swedish Friesian cows with a mean live weight of 650 ± 39 kg were used in the preference test. A number of 16 cows continued in the hygiene test and 15 cows were used in the behaviour study.

Preference study

This study was carried out according to the method described by Magnusson & Michanek (1991). A group of 18 lactating cows was housed loose with access to 18 cubicles. The lying area of the cubicles was of three types: concrete surface, rubber mats (Kreiburg™) and Comfort mats™, 6 of each. The different surfaced cubicles were positioned alternately, that is, first a cubicle with a concrete surface, next one with rubber matting and then one with a Comfort mat™ surface, and so on. The cows remained in the loose housing for a study period of four weeks. During the last week, 4–5 cubicles were video filmed in 24 hour sessions using a time-lapse recorder. Upon analysis, lying time (accuracy <1 min), aggression (cow butted by another animal, being chased out, or chasing out followed by lying down) were noted.

Hygiene studies

Following the preference studies, 16 cows took part in the hygiene studies. They had access to 16 cubicles having the same lying surface for a period of two weeks for each surface. The surfaces were tested in the following order: Comfort mat™, concrete and rubber mats.

Observations of cubicle dirtiness. During each period, the level of hygiene in each cubicle was evaluated by the stable personnel as they cleaned the cubicles. The following was noted for each cubicle both in the morning and evening, when the cows were away for milking, during the study periods:

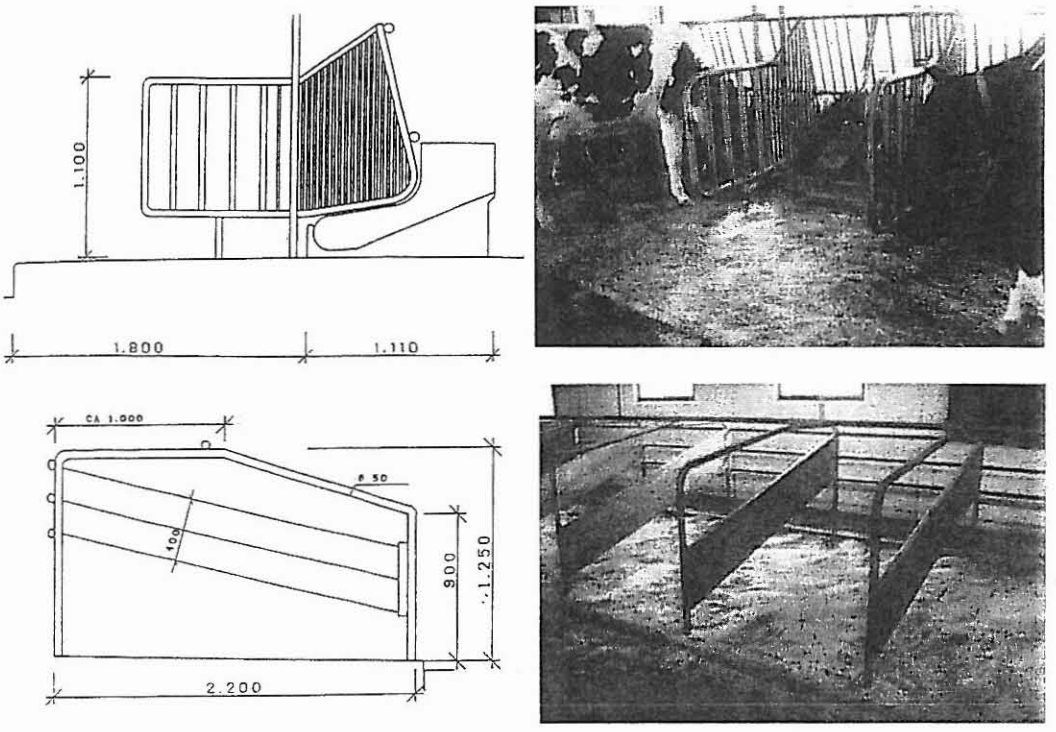

Fig. 1. The design of the cubicles and the tie stalls used in the study.

- the number of cubicles with faeces (having a diameter of ≥ 10 cm),
- the number of cubicles showing milk leakage,
- the number of cubicles having "dispersed dirt".

Cubicle dirtiness was evaluated for morning and evening observations separately. The opinions of the staff regarding the hygiene level and the cleaning properties of the different surfaces were also collected.

Bacteria content. A filter paper (1 × 5 cm) was pressed to the surface using an aseptic cotton pin in the middle of the cubicles, about 45 cm from the rear, which would be the most likely place for the udder being contact with the surface. The portion of the paper being held was then cut off and the remainder placed in a test tube containing 10 ml sterile saline. The presence of bacteria (total colony forming units – CFU) was determined after plating with TGA and aerobic incubation for 72 h at 30°C. The samples were collected at the middle and the end of each study period, prior to placing new bedding in the cubicles. A subjective evaluation of the sampling surface was also done, as being "clean, dirty or intermediately dirty."

Behaviour

The behaviour of the cows with reference to lying down and getting up, was evaluated using a previously reported method (Herlin, 1994; Gustafsson & Lund-Magnussen, 1996). However, in the present investigation, 15 cows from the group studied previously, were moved into tie-stalls having the three different lying surfaces (5 tie-stalls per surface). The tie-stalls have previously been described in detail (Herlin, 1994), and are presented in Fig. 1.

The cows were randomly allotted to the different surfaces in three equal sized groups (5 cows in each group). In the first study period, they stayed on the surface for a week. Then they were moved to a stall with a different type of lying surface. Each surface was tested by ten cows. At the end of each study period, the cows were video recorded using a time-lapse

recorder for a 24 h period. The time (hour, minute, second) was indicated on the video display, so the behaviour could be followed precisely.

Behaviour was analysed according to the length of time spent doing a specific behaviour, the number of intentions and attempts to perform that behaviour and the number of disturbed lying downs and getting ups.

The parameter, lying down, was divided into several steps: preparation period, a *lying down sequence* starting when the nose slowly moved close to the ground (an observation starting 300 seconds before lying down) until the first knee of the cow was in contact with the ground. If her head was lifted for more than ten seconds during this phase, an *intention* was recorded. The termination of *lying down occurred* when the lying down action was completed. An *attempt* was registered if the cow interrupted the process of lying down and got up from her knees. The getting up sequence started with the cow beginning to pull her feet under herself and move her head forward or sideways. The termination of the getting up behaviour was noted when all four feet were in contact with the floor, and the cow was standing in a balanced position.

Disturbed lying down or getting up behaviour was noted in all the cases observed. This occurred when the hind part lay down first, or the cow rose like a horse, where the forequarters first came up in one action.

Statistical analyses

Preference study. The data for each cubicle was processed in order to present the data as per cent of observation time or per cent of total number of observations per cubicle. Analysis of variance was done using a GLM-procedure (SAS statistical program, SAS 1985), as shown below. It allowed the effect of the lying area surface to be separated from the effect of the covariance of the surface type and the row of cubicles and the error.

Model I: $Y_{ijk} = \mu + g_i + g_i \times f_j + e_{ijk}$

where Y_{ijk} is the ijk^{th} observation, m the overall mean, g_i the effect of i^{th} lying area surface ($i = 1, 2, 3$), f_j the effect of the j^{th} row of cubicles ($j = 1, 2$) and e_{ijk} the residual random term.

Hygiene study. The data was statistically analysed by analysis of variance using a GLM-procedure for each of the sampling occasions. As samples were taken from the same cubicle, this was accounted for in the model.

Model II: $Y_{ijk} = \mu + g_i + f_j + e_{ijk}$

where Y_{ijk} is the ijk^{th} observation, μ the overall mean, g_i the effect of i^{th} lying area surface ($i = 1, 2, 3$), f_j the effect of the j^{th} cubicle ($j = 1, 2 \ldots 8$) and e_{ijk} the residual random term.

Behaviour. The means of the lying down and getting up sequences, and the number of intentions per lying down were determined for each cow from the 24 h videotape observations for each surface. Each cow was subjected to two surfaces in a balanced incomplete block design model. The data for each lying surface was compared by analysis of variance using a GLM-procedure (SAS, 1985), according to the following model:

Model III: $Y_{ijkl} = \mu + g_i + f_j + h_k + e_{ijkl}$

where Y_{ijk} is the $ijkl^{th}$ observation, μ the overall mean, g_i the effect of i^{th} lying area surface ($i = 1, 2, 3$), f_j the effect of the j^{th} cow ($j = 1, 2 \ldots 10$), h_k the effect of the treatment order of cows ($k = 1, 2$) and e_{ijkl} the residual random term.

The number of attempts observed and notations of disturbed behaviour were not statistically analysed due to the smallness of the material.

RESULTS

Preference study

The amount of time the cows spent lying down on each surface, expressed as percentage of observation time, and the interactions between the cows in competition for the differ-

Table 1. *Behaviour of cows in cubicles with different surfaces (LS means ± standard error)*

	Concrete	Rubber mats	Comfort mats
% of observation time cows spent lying in cubicle	$18^{a} \pm 3.5$	$55^{b} \pm 3.9$	$71^{c} \pm 3.7$
Percentage of lying cows being			
butted	$8^{a} \pm 5.4$	$13^{ac} \pm 6.0$	$29^{bc} \pm 5.7$
displaced	$8^{a} \pm 4.6$	$9^{a} \pm 5.2$	$24^{b} \pm 4.9$
displaced and displacing cow lying down	$0^{a} \pm 3.5$	$8^{a} \pm 4.0$	$21^{b} \pm 3.8$

Values with different superscripts differ a–b, b–c $p < 0.05$, a–c $p < 0.01$.

Table 2. *Per cent of cubicles with different flooring, categorised into three different hygienic categories in the morning (6.00) and afternoon (15.00). (LS means ± standard error)*

	Concrete	Rubber mats	Comfort mats
Faeces on lying area			
morning (6.00)	$25^{a} \pm 2.0$	$12^{b} \pm 1.9$	$16^{b} \pm 2.1$
afternoon (15.00)	$16^{a} \pm 2.4$	$8^{b} \pm 2.2$	$8^{b} \pm 2.6$
Milk leakage on lying area			
morning (6.00)	$39^{a} \pm 3.6$	$37^{a} \pm 3.4$	$38^{a} \pm 3.8$
afternoon (15.00)	$11^{a} \pm 1.8$	$10^{a} \pm 1.7$	$2^{b} \pm 2.0$
Dispersed dirt in cubicle			
morning (6.00)	$12^{a} \pm 3.6$	$6^{a} \pm 3.3$	$23^{b} \pm 3.7$
afternoon (15.00)	$10^{a} \pm 1.7$	$3^{c} \pm 1.5$	$11^{a} \pm 1.8$

Values with different superscripts differ a–b $p < 0.05$, a–c $p < 0.01$.

Table 3. *Average number of colony forming units (CFU) in different cubicle lying area surfaces. (LS means ± standard error)*

	Concrete	Rubber mats	Comfort mats
Total CFU(Log10) ($n = 24$) in the middle of treatment period	$8.47^{(a)} \pm 0.26$	$9.15^{(b)} \pm 0.25$	$9.11^{(b)} \pm 0.26$
Total CFU(Log10) ($n = 24$) at the end of treatment period	9.23 ± 0.26	9.21 ± 0.26	9.34 ± 0.26

Values with different superscripts within brackets differ with a tendency (a)–(b) $p < 0.1$.

Table 4. *Lying down behaviour and getting up of dairy cows in tie-stalls on concrete, rubber mats and Comfort mats (LS means per cow and 24 hours). Total count on observed attempts and abnormal getting up*

	Concrete	Rubber mats	Comfort mats
Number of lying down and getting up	12.2 ± 1.2	12.5 ± 1.2	14.8 ± 1.2
Lying down sequence 1 (s)	$108^{a} \pm 8.5$	$79^{b} \pm 8.5$	$50^{c} \pm 8.5$
Lying down sequence 2 (s)	$6^{ab} \pm 0.3$	$6^{b} \pm 0.3$	$5^{a} \pm 0.3$
Intentions per lying down	$73^{a} \pm 7.4$	$35^{cd} \pm 7.4$	$24^{d} \pm 7.4$
Attempts, total count	2	2	0
Getting up sequence (s)	9 ± 0.2	8 ± 0.2	8 ± 0.2
Abnormal getting up, total count	1	0	0

Values in rows with different superscript differ significantly, a–b, b–c $p < 0.05$, a–c $p < 0.01$, a–d $p < 0.001$.

ent lying surfaces are presented in Table 1. The lying time, as a per cent of observation time, was significantly longer on the Comfort mats™ than on the rubber matting ($p < 0.05$) or the concrete lying surfaces ($p < 0.01$). Cows (presumably the high ranking animals) also displaced other animals significantly ($p < 0.05$) more from the Comfort mats™ than from the other lying surfaces. No cows were displaced from the concrete lying surfaces.

Hygiene studies

Subjective evaluation of the state of the cubicles. The observations for the subjective evaluation of the hygiene state of the cubicles are shown in Table 2. More cubicles with faeces on the lying surfaces were observed for the concrete lying surfaces than for the other surfaces ($p < 0.05$). No difference in milk leakage in the morning was found between the surfaces, but in the afternoon, less milk leakage was noted on the Comfort mats™ than on the concrete or rubber mats ($p < 0.05$). More cubicles with dispersed dirt were seen in the morning in the cubicles with Comfort mats™ than in the other cubicles ($p < 0.05$). In the afternoon, fewer cubicles with rubber mats were considered to have dispersed dirt ($p < 0.05$).

The personnel noted that when the Comfort mats™ were removed, the surface underneath appeared to be wet. The lying areas with concrete surfaces were considered quite often to be dirty, but were also considered to be easy to keep clean. Similar observations were made for the Comfort mats™, but they were found easy or normal to keep clean. More bedding (especially in the front) remained in these cubicles. The rubber mats were seldom considered to be dirty and were easy to keep clean.

Bacteria studies. The bacterial content of the concrete lying surface appeared to be less in the middle of the treatment period than that of the other lying surfaces, as shown in Table 3 ($p < 0.1$). However, there was a great variation between individual cubicles. There was a good relationship between the subjective scoring of the sampling site and the bacterial counts.

Behaviour studies

The preparation time required by the cows to lie down (Table 4) was significantly shorter on the Comfort mats™ ($p < 0.01$ and $p < 0.05$, respectively), than on the other surfaces (Comfort mats™ 50 s, rubber mats 78 s and concrete 108 s). There was also a significant difference between the rubber mats and the concrete flooring for preparation time to lie down ($p < 0.05$). A few attempts and disturbed getting ups were noted for the concrete and the rubber mat lying surfaces.

DISCUSSION

It was clear from the observations made in this investigation that, not unexpectedly, the cows preferred the most soft lying area. The Comfort mat™ was superior to the other surfaces compared in this respect. This supports the observations of earlier studies (Wander & Fricke, 1974; Nilsson, 1988; Magnusson & Michanek, 1991). A lying area of concrete with small amounts of bedding appears to be strongly disliked by cows and should be avoided.

In addition, the hygiene of concrete lying surfaces was also worse than that of the other surfaces. It has previously been suggested that the faecal contamination of cubicles was due to the cows defecating while lying down (Herlin et al., 1994). The more frequent defecation occurring on the concrete surface may be related to difficulties or pain in getting up or lying down associated with this surface. Milk leakage was less on the Comfort mats™ in the afternoon but no differences were seen in the morning with respect to this parameter. More Comfort mat™ cubicles were seen with dispersed dirt in the morning, which may be due to the special surface structure retaining bedding and dirt. However, no difference was observed between the Comfort mat™ and the concrete surfaces in the afternoon with respect to this parameter.

The bacteria flora of the surfaces generally represented the sampling sites. The surface properties and the presence of suitable substrate (faeces and milk) may promote the growth of bacteria. This may have been true

for the concrete surface but also for the Comfort matting because dirt, mainly from the claws appeared to easily stick to the surface of this matting. The material in the Comfort mats™ would not promote bacteria growth according to the manufacturer. The observation of a wet floor surface underneath the Comfort mats™ may have to do with thermal gradients and the occurrence of condensation of water. It may also occur under conventional rubber mats.

The behavioural studies showed that the Comfort mats™ facilitated lying down behaviour since the lying down sequence was shorter and there were fewer intentions per lying down. The connection of improved lying area quality and lying down behaviour is supported by several authors (Andreae & Smidt, 1982; Krohn & Munksgaard, 1993; Herlin, 1994). It was considered that the cows did not to any great extent associate this behaviour with pain, anxiety or lack of control. The presence of common rubber matting also appeared to facilitate lying down, but evidently, the softness of the Comfort mats™ clearly improved this behaviour assuming adequate non slipping properties of the different surfaces. The getting up behaviour time sequence is not a good indicator of animal welfare as the getting up movements are relying on a rotational movement in order to put the hind limbs in place and to reduce the muscular effort in the rising (Herlin, 1994). This is also supported by the present study. It is in poorly designed tie-stalls or cubicles where getting up behaviour is physically hindered, a frequent use of disturbed movement patterns upon rising, such as rising like a horse will occur.

CONCLUSIONS

- Comfort mats™ were shown to be superior to both rubber mats and concrete lying surfaces in the preference and in the behaviour studies. This was probably due to the softness of the Comfort mats™. The comparison can however not determine the optimum softness of a lying area for dairy cows.
- Concrete should be avoided in the lying area for cattle due to the negative influence on comfort and behaviour and the higher frequency of contaminated cubicles.
- The contamination of a cubicle lying area with dirt is due to the cows defecating while lying down and dirt carried in on the claws.
- A softer lying area (e.g. rubber mats and Comfort mats™) appears to promote hygiene in the cubicle, by reducing the frequency of cows defecating when lying as lying down and getting up behaviour is facilitated.

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