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Hygiene Studies In Cubicle Cowsheds with Different Floor Systems in the Passages

Hygienstudier i liggbåsstall med olika golvsystem i transportgångarna

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PREFACE

This 20 credit thesis is written as a part of the Biotechnology program (MSc) at the Swedish University of Agricultural Sciences. It is a part of the project "Development and evaluation of floor systems in animal passages in dairy cubicle cowsheds", which has been financed by SLF, "*Stiftelsen Lantbruksforskning*", the Swedish Farmers' Foundation for Agricultural Research.

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ABSTRACT

The hygiene in a cowshed is extremely important for the cows well being and health and when it comes to keep a high production of quality milk. As more and more producers choose loose-housing systems for their cows the demand for better buildings and equipment is increasing. This study concentrates on how the floor systems used in the alleys and the cubicles height over the floor affects the hygiene in the cowshed. There are many aspects to take into consideration besides hygiene and well being of the cows but this study can be seen as a part of the recommendations how to design a cowshed.

The different floor systems that were involved in the study were two compartments with mastic asphalt and scrapes with cubicles that were situated with different height over the floor and a compartment with concrete slatted floor without scrapes.

In this study several examinations were performed to compare the hygiene in the three compartments. Ash content analysis was performed to give the amount of manure on the lying area in the cubicles. The hygiene was further compared with bacterial analyses using coliform bacteria and spores from *Clostridium tyrobutyricum* and *Bacillus cereus*. The dirtiness of the udders and teats were estimated visually by giving scores on a continuous scale. To get some indication of how the milk quality was affected by the hygiene in the cows' local environment somatic cell counts were recorded and analysed.

All results indicate that the hygiene is best in the compartment with mastic asphalt and scrapes with cubicles situated higher over the floor. The amount of manure in the cubicles was lower compared to the other compartments and the number of coliform bacteria was lower. The animals were much cleaner in this compartment and the somatic cell count was lower. The compartment with mastic asphalt and low situated cubicles seemed to be the one with the most poorly hygiene in all experiments except the ash content analysis were the slatted floor compartment was the one with the highest amount of manure.

The conclusion drawn from this study is that cubicles well elevated above the alley is important to maintain a good hygiene for the cows in the lying area. Whether the slatted floor without scrapes or the mastic asphalt floor with scrapes gives the best hygiene when the cubicles are situated at the same low height is difficult to confirm from this study since the results point in different directions.

1 INTRODUCTION

The Swedish dairy industry is increasingly turning from tied housing to loose housing systems in cubicles. The main reason for this is that the average herd is becoming larger and the time spent per cow has to decrease in order to maintain profitability. The welfare aspect of the cows is also an important question that drives the development towards loose housing systems. In the beginning of 2003 approximately 30 % of all cows in Sweden where housed in loose-housing systems and if this trend continues that number will be 50 % year 2010 (Sällvik & Dolby, 2003). As the loose housing systems becomes more frequently employed the demand for better buildings and barn equipment increases.

Studies have shown that there are both advantages and disadvantages with loose housing cowsheds. Cows in loose-housing systems have a bigger opportunity to perform their natural behaviour when compared to tied cows. The social and physical stress of the cows can on the other hand be larger in loose housing systems. Studies have also shown that changeover from tied systems to loose housing systems can lead to deterioration in claw and leg health. Bergsten and Herlin (1996) showed that the risk for lameness and claw lesions is significantly higher for dairy cows in loose housing systems than for cows tied in stalls.

The hygiene in the barn is a very important factor that varies with different housing systems. An important factor determining the magnitude of these problems in loose housing systems is the type of floor system used in the alleys. A floor surface that is difficult to keep clean affect the risk of claw related diseases and can also lead to dirty claws, udder and teats (Bergsten, 2001). The increased amount of manure in the cubicles and on the cows can lead to decreased udder health and reduced milk quality and can result in increased costs and reduced milk production (Ekman, 1998).

The ongoing project "Development and evaluation of floor systems in animal passages in dairy cubicle cowsheds" is integrated with the project "Dairy cows' locomotion comfort and claw lesions in loose-housing systems – associations with flooring, claw conformation, lameness and behaviour", which is a part of the international "Lamecow" project. The objective of that project is to study short-term and long term effects of floor surfaces with varying hardness, structure and hygiene in loose housing systems on dairy cows locomotor's apparatus. The studies are focused on questions related to animal environment, well being and health.

At the experimental farm of Swedish University of Agricultural Science in Alnarp, Alnarp Mellangård, there is a compartment with 100 dairy cows in cubicles. This compartment is divided into five sub compartments with 20 cows, which have the same layout with the exception of with and without feed-stalls and different floor system. For the time being there is mastic asphalt and rubber mats with scrapes in the alleys, and also a control compartment with slatted concrete floor without scrapes. The cubicles height over the floor also differs between the different compartments.

1.1 The objective of the study

The objective of the study was to give recommendations how floor-systems in passages should be designed and managed in order to provide a good hygiene and good conditions for animal health.
The aim of this project has been to:

- Examine if the floor-system in the passages affect the hygiene in the cubicles.
- Examine if the cubicles height over the alleys affects the hygiene in the cubicles.
- Examine whether the floor-system affect the dirtiness of the animals, i.e. the dirtiness of the udders and the teats.
- Examine if differences in somatic cell count can be seen in milk from cows from the different compartments.

1.2 The issue

The following issues are dealt with in this examination project:
The department with concrete slatted floor without scrapes is to be compared with the compartment with mastic asphalt and scrapes. There were two departments with mastic asphalt and they differed in the presence and non-presence of feed-stalls and in the cubicles height over the floor in the passageways. As the feed-stalls are disregarded from in this study the comparison will be performed with concentration on the cubicles height over the floor.
The cubicles were situated 10 cm above the floor in the slatted floor compartment and in one of the mastic asphalt compartments. In the other compartment with mastic asphalt the cubicles height are 17 cm.
The compartments with rubber mats will be disregarded from in this project, because no differences between rubber mats and mastic asphalt are expected when it comes to hygiene.
The following questions were to be answered:

- How does the floor-system in the passages affect the hygiene in the cubicles and the dirtiness of the cows? Does the amount of manure that the animals bring to the cubicles differ depending on the floor-system in the alley?
- To what extent does the cubicles height over the passages affect the hygiene in the cubicles?
- If differences in dirtiness are observed between animals from the different compartments, will these differences be reflected in reduced milk quality such as increased SCC (somatic cell count)?

1.3 Hypothesis

When comparing a solid floor with scrapes to a slatted floor without scrapes the hypothesis was that the solid floor with scrapes was easier to keep clean. This of course depends on how often and when the scrapes are turned on. Anyway, the area closest to the cubicles is easier to keep clean with scrapes than on floor without scrapes where manure seems to accumulate and need manually removal. The fact that the floor surface is believed to be cleaner on a floor with scrapes leads to the hypothesis that the cubicle lying surface also should be cleaner when the floor has scrapes. In this study this will be indicated by a lower amount of manure on the lying surface and also a lower amount of spores and bacteria. The cows will have cleaner udders and teats and the somatic cell count from these cows will be lower.

The other question in this study was how the cubicles height over the floor affected the hygiene on the lying surface and on the animals. To get an answer to this the two compartments with mastic asphalt was compared. One compartment has cubicles that were situated twice as high over the floor surface as the other one. The hypothesis for this was that the results will show that the high elevated cubicles had a better hygiene in form of low manure content and fewer spores/bacteria and that the cows in this compartment will be cleaner. The somatic cell count should also be lower in this compartment.

2 REVIEW

2.1 Technical development of floor systems

2.1.1 Solid floors

Development of solid floors in cubicle cowsheds was one of the first steps to reduce the emission of ammonia. Draining floors, especially slatted floors with manure storage below the floor has proven to result in large emission of ammonia. The development of solid floors has preferentially taken place in the Netherlands.

A number of alternatives of solid floors has been produced and tested in order to reduce the slipperiness, to maintain a clean and dry surface, to improve the durability and to avoid far too hard materials. In the Netherlands a leaning floor with 30 mm deep and 35 mm wide grooves was developed partly for increased drainage and partly to reduce the slipperiness (Swiersta et al., 1997). The floor was scraped every second hour with a scrape. These floors reduced the emission of ammonia with 46 % compared to traditional slatted floors.

To scrape the floors more frequently has also proved to result in cleaner floors. A floor with a plane surface without liquid drainage was scraped every 15 minutes compared to every second hour and the ammonia emission decreased with 5 %. The explanation to this rather slight effect was that the scrapes spread the urine over a greater surface. Placing frequent urine drainages can reduce these problems (Braam & Swiersta, 1997).

To flush the floor with liquid is another way to reduce the emission of ammonia and to keep the floors clean (Irps, 1995). (Braam & Swiersta, 1997) used 6 litres per cow and day, which resulted in 65 % reduction of ammonia emission from the floor. There was no reporting whether the floor got cleaner or not.

Surface treatment of solid concrete floors can affect the floors qualities in many ways, for example reduce the aging, increase the friction and increase the drainage of urine (Swiersta et al., 1994). The aging in form of increased slipperiness is a known phenomenon. Experiments have been performed where a 6 mm epoxide coat was placed on the floor and this reduced the wearing of the surface.

The problems with aging when using mastic asphalt on concrete floors in passages are less when it comes to increased slipperiness. The mastic asphalt can however be slippery when it is dry and therefore scrapes on a mastic asphalt floor should be distanced a couple of millimetres from the surface (Herrmann, 1999).

To make patterns in the floor surfaces can make the floor less slippery and facilitate the urine drainage. One disadvantage with this is that urine and manure can remain in the patterns. In Sweden a floor has been produced that has patterns but at the same time has a slope against the centre of the passageway (Karlsson, 1999). The floor was scraped once an hour and this leads to a dry and clean floor according to the owner.

2.1.2 Slatted floors

The dimension of the slatted floor affects the draining capacity and the loading of the hoofs. The wider slats and the narrower slots the less load but the poorer draining capacity are obtained (Dämmerich, 1987).

To furnish the slatted floors with rubber covering has been developed to increase the well being for the cows. This is however rather expensive and the spread of this system is therefore limited.

Flushing of slatted floors has reduced ammonia emission by 35% reduction (Oosthoek et al., 1990) and also reduced the bacterial activity on the floor (Kroodsma, 1992).

Other floor materials such as plastic, wood or metal can be used instead of concrete but they may have an insufficient strength and durability or they are too slippery. Rubber covered slatted floors of steel or wood can on the other hand be suitable (Lundberg, 1999).

2.2 Floor-systems and hygiene

The hygiene of the floor in the passages has a great impact on animal health problems as hoof and udder suffering as well as for the milk quality. The design of floor systems is therefore very important for a persistent and long-term profitable milk production. The floor is the structure in the cowshed that the animals are in closest contact with (Nilsson et al. 1992).

Characteristics of the floor that causes direct physical injuries are primary related to wearing of hoofs, hardness, slipperiness and the surface profile. Also the animal's behaviour can be affected (Metz & Wierenga, 1987). The quality to be focused on in this essay is the floor surfaces dirtying and dampness. Besides that the slipperiness increases, these factors affect the hygiene of the animals. This of course affects the hoofs but also the rest of the animal body including the udder and teats. Studies have been made to measure the dirtiness and the dampness on the floor surface. In on study a filtering paper was used to measure the dampness. In another study the dirtying was measured by collecting the excrement from a fixed area on the floor surface (Pfadler, 1981).

When it comes to hoof health, cows in cubicles have a poorer hoof health compared to animals in tie-stalls (Bergsten & Herlin, 1996). On the contrary, the udder health is better in cubicles and than in tie-stalls (Konggaard, 1980). How the floors in the passages affect the udder health has not been examined particularly. Ekman (1998) reports several studies that identify risk factors and preventing factors for management and housing of dairy cows with emphasis on udder health. These factors are quite general and include: good hygiene and a clean environment, dry bedding, clean udder and teats, clean passages and floors. Ekman studied Swedish dairy farms with low bulk milk somatic cell counts (LC) and farms with high cell counts (HC) for seven years. He studied environmental factors affecting udder health and found out that the LC farmers used significantly more bedding of better quality than the HC farmers. The LC farmers also used straw instead of sawdust to a higher extent. There was also a strong trend that the effectiveness of the urine system was better on LC than on HC farms. He also found out that herd size is a risk factor for elevated somatic cell counts. On the other hand, other studies have shown the opposite and Ekman questioned if it was the herd size *per se* that lead to higher cell counts or if it was the fact that the HC farmers had more cows than they could handle. Ekman concluded "the structure and the condition of the stall surface is of great importance for cow comfort, for her ability to rise without treading on her teats, and for providing a clean and reasonably soft lying place".

Rosbacke (2003) examined the cleanliness of two different slatted floors in cubicles for dairy cows. She compared a conventional (125/40-mm) slatted floor to a modified (100/30-mm) slatted floor. The cleanliness was studied by collecting and weighing the manure on the top of the slats in six 60 x 80-cm test squares in each compartment. The results showed that the modified floor is as clean as the conventional one, and even cleaner at the edges of the alley.

2.3 Mastitis

According to Zdanowicz (1999) mastitis is one of the most complex and costly diseases of dairy cows. The disease has an enormous economic impact for a producer due to lowered milk yield, reduced milk quality and poor animal health.

According to Bergsten et al. (1997) the most common cause of mastitis is a bacterial infection via the teat canal. The somatic cell count increase as a defence against this infection and the composition of the milk changes and this leads to a deterioration of the milk quality. Even a sub clinical mastitis results in increased somatic cell count. However, there are other things that affect the cell count i.e. lactation number, production levels, stage of lactation and breed. The hygiene in the cubicles is one of many management factors that affect the risk of infection. Environmental conditions will affect the rate and magnitude of bacterial growth in the cow's surroundings. Exposure to manure in cow housing areas can influence the rate of clinical mastitis (Schreiner & Ruegg, 2003). The most obvious source of environmental infections is the bedding because the udders come into direct contact with bacterial populations in the bedding (Zdanowicz, 1999).

Studies have shown that there is a relationship between udder and leg hygiene and subclinical mastitis. Schreiner and Ruegg (2003) studied 1250 lactating dairy cows from eight commercial dairy farms. Udder and leg hygiene scores was recorded and compared to bacteriological cultures of milk samples and monthly individual SCC values. Udder hygiene scores were significantly associated with leg hygiene scores and linear somatic cell scores increased as udder hygiene scores increased. Further, animals with udders considered as dirty were 1,5 times more likely to have major pathogens isolated from milk samples compared to animals with udders characterized as clean.

Other studies on herd-basis have shown that the environment and the cows themselves were cleaner for herds that produced milk with lower SCC values compared with herds with higher bulk tank SCC values (Barkema et al., 1998).

2.4 Bacteria and spores from bacteria

Clostridia are gram-negative rod-shaped bacteria. They are obligate anaerobic organisms and there are motile and non-motile forms. They are commonly found in soil, sewage, marine sediment, decaying vegetation, animal and plant products and in the intestinal tract of insects, man and other vertebrates (Jonsson 1989). *Clostridia* form endospores within their cells. Endospores are differentiated cells that are very resistant to heat and cannot be easily destroyed (Madigan et al., 2000).

Spores from *Clostridia* in the milk affect the ability to produce certain kinds of cheese. These bacteria can multiply in silage and are commonly called winter spores. They are transferred as spores to the teats via contaminations and are then further transferred to the teat canal and to the milk (Bergsten, 1997).

Clostridia spores were used to compare hygiene for cows kept in cubicles or tie-stalls (Herlin & Christiansson, 1993). Milk from cows kept in cubicles contained 6-10 times more spores the in the milk from cows kept in tie-stalls thus suggesting differences in bedding management of stalls/cubicles.

Bacillus cereus is a gram positive, facultative, aerobe bacterium and they form endospores just like *Clostrida* (Kolstrup et al., 1999). *Bacillus cereus* is found in soil and are a major problem in summer for grazing cows when spores in the soil contaminates the teats and eventually ends up in the milk. High content of spores in milk has also been established during the indoor period. *Bacillus cereus* is the factor that limits the keeping qualities in milk.

Coliform bacteria are rod shaped, gram-negative bacteria that exists in water, feed, contaminated bedding etc. One example of a coliform bacterium is *Escherichia coli*. It is widely represented in manure and causes acute, clinical mastitis often around calving. *Klebsiella pneumonia* is another coliform bacterium.

3 MATERIALS AND METHODS

3.1 Experimental design

3.1.1 Housing and indoor equipment

The experiments have been performed in the cubicle cowshed at the animal experimental station of the Swedish University of Agricultural Sciences at Alnarp in southern Sweden. The cubicle cowshed is a part of a larger building complex. The cowshed is a heat-isolated building with self-supporting roof trusses and structural concrete element walls. The ventilation is temperature controlled mechanical negative pressure ventilation.

The cubicle cowshed has in total 206 cubicles. The reconstructed part accommodates 80 cows and is divided into four compartments. There is also a control group with 20 cubicles and concrete slatted floor in the passages (see fig. 1). The width of the slats is 125 mm and slots width are 40 mm.

The four compartments in the reconstructed part have the same layout with the exception of with and without feed-stalls and different floor systems. Earlier there were passages with and without scrapes on slatted concrete floor, with and without feed-stalls, respectively. Today there are passages with mastic asphalt and rubber mats with scrapes. The two opposite test groups closest to the control group have mastic asphalt in the passages but only one have feed-stalls. There is also a difference in the cubicles height over the passages between those two compartments. The one with feed-stalls have ca 10 cm high cubicles and the other one have ca 20 cm high cubicles. The cubicles height in the slatted compartment is ca 10 cm.

Every compartment has in total 21cubicles with the size of 1250 x 2400 mm. The cubicle floor is covered with 30 mm thick polymeric mats (DeLaval Cow Mat CM30L). The passages between the cubicle rows are 16 m long per compartment and 2.2 m wide. There is one computerised feed station for concentrates in each compartment.

The scrapes in the two mastic asphalt compartments turned on 11 times daily. New sawdust is provided to the cubicles twice a week and the approximate amount is 3.5 – 7 kg per cubicle per week. The cubicles are cleaned twice daily and sawdust that has accumulated in the front of the cubicles is mowed backwards in the cubicles.

Previous studies at the experimental station have been performed on the amount of manure in the passageways on mastic asphalt and slatted floor respectively. The results from these studies show that the average amount of manure is 0.8 kg manure per m^2 on mastic asphalt and the same value for the slatted floor is approximately 50 % higher. The studies also show that the amount of manure in the area closets to the cubicles is higher than the amount of manure in the middle of the passageways.

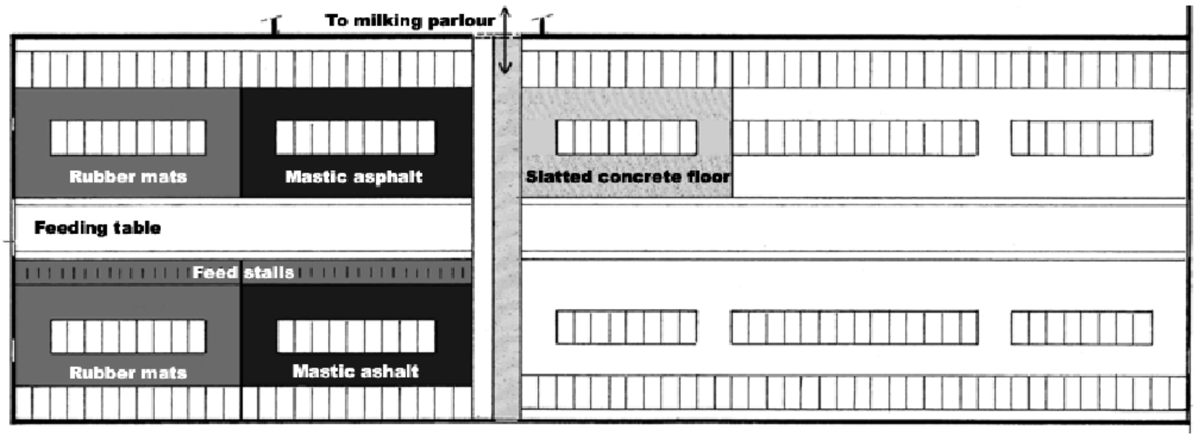

Figure 1. The figure shows the cubicle cowshed layout (Michael Ventorp).

3.1.2 Animals

The entire herd is of Swedish Holstein breed. The total number of cows was 180 with a milk yield of 9500 kg ECM (energy corrected milk). The bulk milk somatic cell count for 2003/2004 was 195 000 /ml. The system for calving is an all year around calving season system. The feed given to the cows is concentrate, mixed ration of silage and maize and some hay.

There were in total 60 cows included in this study. 40 cows in the two different mastic asphalt compartments and 20 cows in the slatted floor compartment. A division of cows in different lactations is made between the different groups, so that the number of cows in each lactation is the same in each group, i.e. the cows are divided in rotating groups after calving with respect to lactation. The cows are in average at the same time point after calving in each group. The number of cows in the first lactation in each group were approximately 10.

3.2 Cubicle floor manure contamination

Analysis of ash content in a sample with manure and sawdust can be used to measure the amount of manure in that sample. This can be done just because manure contains ash but the ash content in sawdust is zero or close to zero.

The samples were collected during a two weeks period in March. Samples from nine cubicles from the three different compartments were collected at three occasions. A total number of 81 samples were analyzed. Collection of the samples was done just before new bedding was provided in the cubicles. New bedding was provided two days a week in each compartment.

A frame with the size of 600 mm x 600 mm was placed 200 mm from the rear edge of the cubicle and the bedding material from inside this frame was collected. The size of the frames was adjusted to the udders contact surface on the rubber carpet. The amount collected from inside the frame varied from approximately 50 g to a couple of hundred grams. The samples were let to dry in a drying cupboard at 100 degree Celsius for approximately eight hours. The samples were weighed before and after drying to get the dry matter content. The material was ground by the National Veterinary Institute in Uppsala, using a falling number grinder from the manufacturer Kamas. The size of the sieve was 1 mm.

Two g of each milled sample was put in an oven at 650 degree Celsius in 15 min. The ash content in pure manure and pure sawdust was also measured in order to do the calculations.

Ash content in manure = 0.17
Ash content in sawdust = 0

The amount of manure in each sample was then calculated as follows:

$(X - 0.17) / (0 - 0.17) \times 100 = Y$

$Z = 100 - Y$

Amount of manure in gram = DM x Z

X = ash content in sample
Y = percent sawdust in sample
Z = percent manure in sample
DM = dry matter content

The amount of manure in gram was the most interesting parameter since amount manure in percent has to do with how much new sawdust is added.

3.3 Analysis of spores from *Clostridium tyrobutyricum*

Bacterial analysis of material from the cubicles is a way to measure the contamination of manure in the bedding material. Spores can be used as a measurement instead of living bacteria since they are present in a smaller number then living bacteria.

The samples were collected during a two weeks period in March. Samples from nine cubicles from the three different compartments were collected at three occasions. A total number of 81 samples were collected. Collection of the samples was done just before new bedding was provided in the cubicles. New bedding is provided two days a week in each compartment.

25 g of the samples and 225 ml 0.3% peptone water was homogenized in a Stomacher in 60s. By heat-treatment of the mixture in 10 min at 80°C the vegetative bacteria were killed but the spores survived and got activated. After the heat-treatment the mixture was let to cold down to 10-15°C.

A dilution series down to log –6 was performed in 9ml peptone water tubes (0.85% NaCl and 0.1% peptone) in 10-steps. 0.1 ml from each dilution was spread on RCM-plates with and without D-cycloserine. Addition of 2 ppm D-cycloserine makes the substrate more selective by inhibiting growth of facultative anaerobe Bacillus species. The plates were incubated upside-down in anaerobic clock at 37°C in 2 days.

3.4 Analysis of spores from *Bacillus cereus*

The samples were collected during a two weeks period in March. Samples from nine cubicles from the three different compartments were collected at three occasions. A total number of 81 samples were collected. Collection of the samples was done just before new bedding was provided in the cubicles. New bedding is provided two days a week in each compartment.

25 g of the samples and 225 ml 0.3% peptone water was homogenized in a Stomacher in 60s. By heat-treatment of the mixture in 10 min at 72°C the vegetative bacteria were killed but the spores survived and got activated. After the heat-treatment the mixture was let to cold down to 10°C.

A dilution series down to log –3 was performed in 9ml peptone water tubes (0.85% NaCl and 0.1% peptone) in 10-steps. 0.1 ml from each dilution was spread on blood agar plates. The plates were incubated upside-down at 30°C in 24 hours.

3.5 Analysis of coliform bacteria

The samples were collected during a two weeks period in March. Samples from five cubicles from the three different compartments were collected at three occasions. A total number of 45 samples were collected.

Samples were collected 8 hours after new bedding were provided in the cubicles. This was done to minimize the time the bacteria will have for replication. The number of coliform bacteria tends to escalate very rapidly with time. Eight hours after cleaning the bacteria are still in a growth phase and have not yet reached the maximum of growth. The dry matter content in the material was so low that the water activity did not limit the growth of the bacteria.
Because of the fact that the samples were collected during a short period of time, approximately two weeks, can no long time effects be expected.

Samples of 25 g of and 225 ml 0.3% peptone water was homogenized in a Stomacher in 60s.
A dilution series down to log –5 was performed in 9ml peptone water tubes (0.85% NaCl and 0.1% peptone) in 10-steps. 1 ml was put on a plate and was cast in VRA-agar. The plates were incubated at 30°C in 24 hours and the number of colonies was calculated.

3.6 Dirtiness scoring of udders and teats

The dirtiness of udder and teats was examined in connection with morning milking at three occasions for each compartment. Twenty cows in each compartment were examined so a total of 180 examinations were done on udders and teats respectively.

The dirtiness of the udders and teats was estimated visually and were given scores between 0 and 100 % on a continuous scale, where 0 % stands for completely free of dirt and 100 % stands for completely covered with dirt. The lower part of the udder and the teats and teat tips were examined separately. The method used is a modification of a previously accomplished method (Almér, 1996.).

3.7 Analysis of somatic cell counts

Twenty cows in each of the three compartments were compared with the emphasis on their somatic cell count from milk samples collected twice a month from September 2003 to April 2004.

Twice a month individual cow SCC data were assembled and geometric mean values for each group were calculated. Geometric mean values were used instead of normal mean values in order to smooth out the extreme differences in somatic cell count that for example comes with mastitis.

3.8 Statistical methods

The statistical program that was used in this project was from Minitab Inc. The method used was a general linear model and the model used is as follows:

$y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$,

Where
y is the dependent variable, for example manure
μ is the overall mean
α is type of floor
β is cubicle curb height (high and low)
e is error/variation at random

No interaction between the variables was noticed in the analysis.

4 RESULTS AND DISCUSSION

4.1 Cubicle floor manure contamination

The results from the ash content analysis showed that the mastic asphalt compartment with high cubicles had the lowest content of manure on the lying surface (see table 1). The mean value of manure on these cubicles was 18.5 g while the highest amount of manure was found on the cubicles in the slatted floor compartment with 34.9 g. The manure content in percent has to do with how much new bedding material was provided in each cubicle and are therefore somewhat misleading to consider since this amount varies.

These results were according to the stated hypothesis expected and are very satisfying. However, one could have expected a greater difference between the low mastic asphalt compartment and the slatted floor compartment. Since the cubicles in these compartments had the same height over the floor one could believe that this is a quite important factor for the hygiene in the cubicles.

Although these results seem reliable one has to take into consideration that some management factors may affect the results. There are different labours that have varying procedure when it comes to clean the cubicles and to provide new bedding material.

The probability values for factor cubicle curb height show statistical significance, which means that there is a high probability that the model used is correct (see table 1). The p-values for the factor floor type on the other hand show no statistical significance but yet a tendency for manure in percentage.

Table 1. The dry-matter content in percent of the samples from the different compartments. It also shows the ash content in percent and the proportions of bedding material and manure in the different samples. From these values manure content in gram has been calculated. Probability values for manure in percent and for manure in gram at factor floor type and at factor curb height is presented.

	Mastic Asphalt (Low)	Mastic Asphalt (High)	Slatted floor (Low)	Prob. value at factor floor type	Prob. value at factor curb height
DM-content, %	38.0 ± 10.0	50.0 ± 8.6	42.0 ± 9.9		
Ash content (%)	13.8 ± 3.2	6.0 ± 1.5	14.3 ± 5.6		
Bedding material, %	18.8 ± 19.0	63.4 ± 8.6	15.9 ± 33.2		
Manure, %	81.2 ± 19.0	36.6 ± 8.6	84.1 ± 33.2	0.044	0.000
Manure, g	30.9 ± 7.3	18.5 ± 4.3	34.9 ± 13.8	0.373	0.009

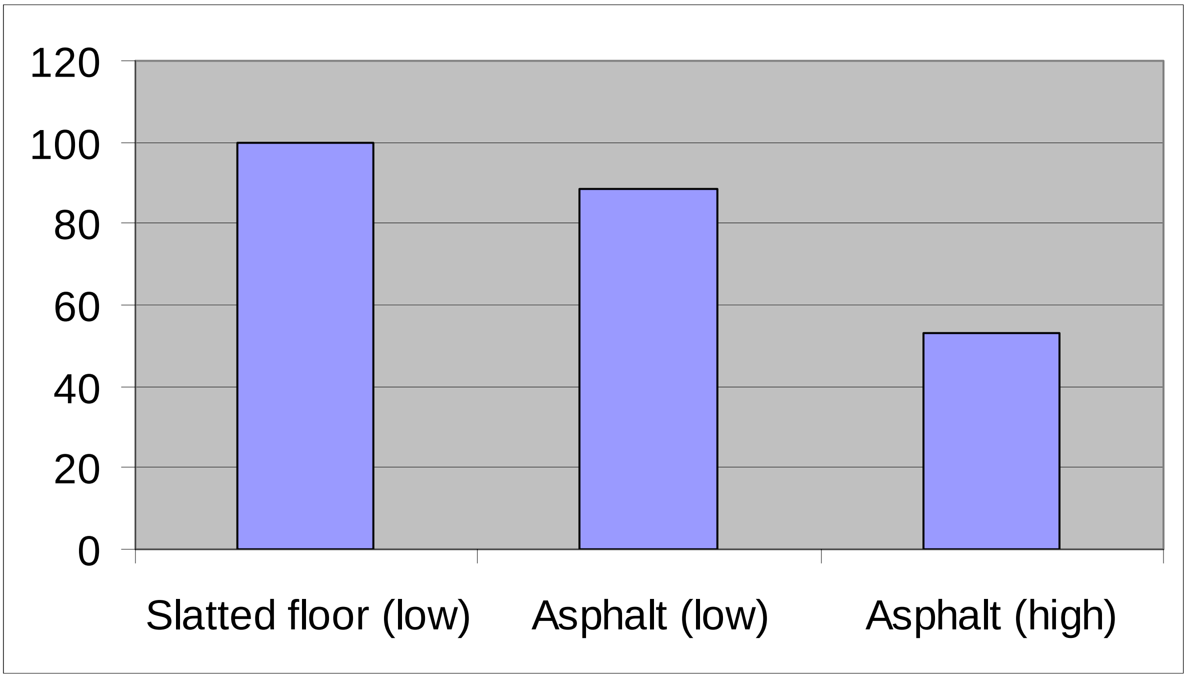

Figure 2. The results from the cubicle floor manure contamination.The manure contamination in the two compartments with asphalt can here be wieved in relation to the manure contamination in the slatted floor compartment here presented as a referens of 100.

4.2 Spores from *Clostridia* and *Bacillus*

The analysis of spores from *Clostridia* and *Bacillus cereus* provided no applicable results. The agar plate surfaces showed no signs of spores or bacteria. Spores from *Clostridia* were expected and some colonies should be visible. The reason for this was probably some error in the performance of the experiment. The procedure was quite complicated and the material used could have been better.

4.3 Coliform bacteria

The results from this bacteriological experiment show that the cubicles in the mastic asphalt "low" compartment had the highest number of coliform bacteria (see fig 3). The exact number of colony forming units is however quite uninteresting but the results show that the "low" compartment had more than twice as many bacteria as the "high" compartment (see table 2). Here the results differ from the results from the ash content analysis where the slatted compartment had the most dirty cubicle surfaces. The most interesting thing is however that the results are pointing out that the mastic asphalt compartment with high cubicles seems to be the one with the best hygiene.

The p-values show statistical significance for factor cubicle curb height but non for factor floor type (see table 2). This means that cubicle curb height seem to have something to do with the dirtying on the cubicles in form of coliform bacteria. It also point out that a larger sample selection can make the results more reliable.

Table 2. The logarithmic values of colony forming units (CFU) per gram sample from each compartment respectively and p-values from the statistical analysis

	Mastic Asphalt (Low)	Mastic asphalt (High)	Slatted floor (Low)	Prob. value at factor floor type	Prob. value at factor cubicle curb height
CFU per gram sample	5.43 ± 0.54	5.07 ± 0.48	5.25 ± 0.53	0.329	0.057

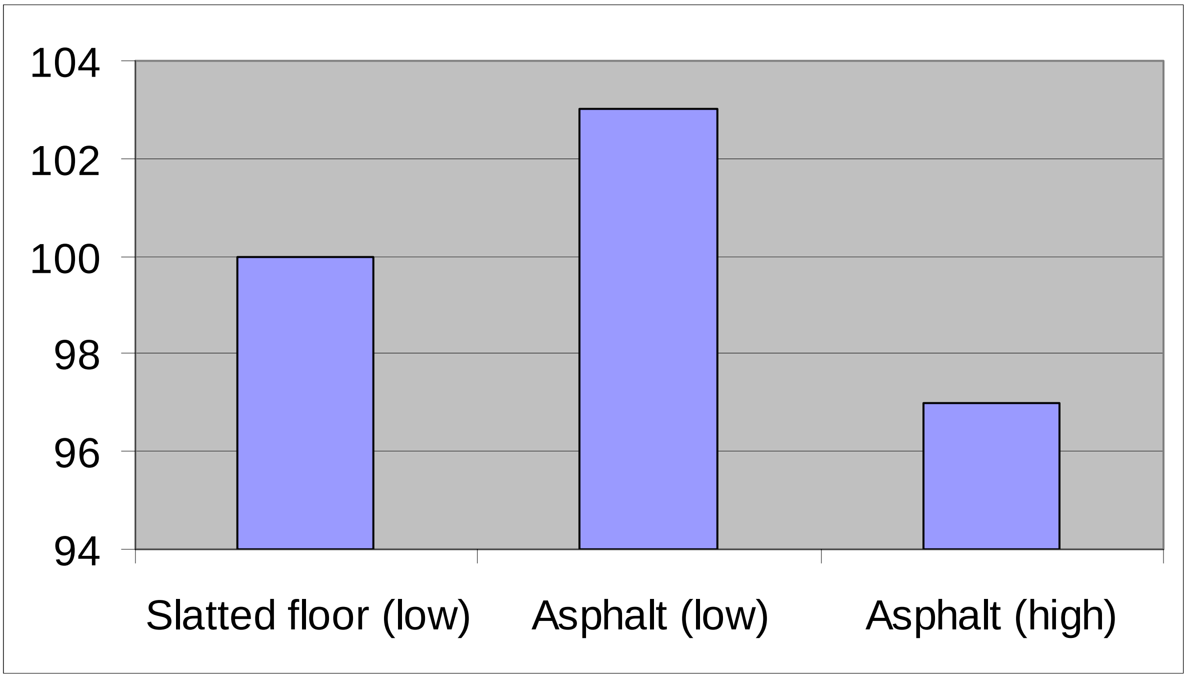

Figure 3. The results from the coliform bacteria analysis. The amount of bacteria in the two compartments with asphalt can here be wieved in relation to the amount of bacteria in the slatted floor compartment here presented as a referens of 100.

4.4 Dirtiness scoring of udders and teats

The udder and teat hygiene examination is a matter of individual judgement so the actual marks are not the interesting thing here as are the relativity between the marks from the three compartments. However, the cows in the mastic asphalt "high" compartment seemed to have the cleanest udder and teats (see table 3). The cows in the mastic asphalt "low" compartment had the most dirty udder and teats. These results, as the others, depends on how careful the cubicles were cleaned and how much new bedding material that were provided. However, the results however show a rather big difference between the cleanest and most dirty cows (see fig 4).

The p-values show statistical significance for all factors for both udder and teat score (see table 3). Besides floor type and cubicle curb height, present lactation number for the cows where tested as a factor.

Table 3. The means score from the udder and teat hygiene examination, respectively and p-values from the statistical analysis

	Mastic Asphalt (Low)	Mastic asphalt (High)	Slatted floor (Low)	Prob. value at factor floor type	Prob. value at factor cubicle curb height	Prob. value at factor lactation
Means score Udder	17.3 ± 8.2	6.1 ± 6.6	12.3 ± 7.6	0.026	0.000	0.029
Means score Teats	16.3 ± 9.6	6.8 ± 4.7	11.4 ± 5.9	0.028	0.000	0.042

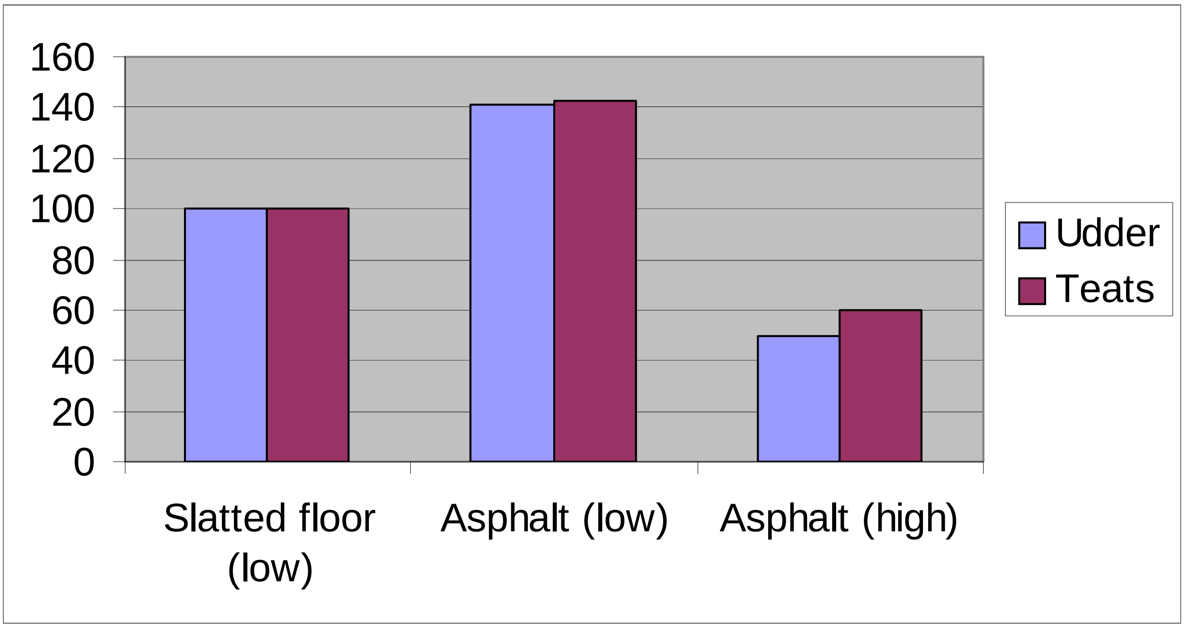

Figure 4. The results from the udder and teat hygiene analysis. The udder and teat score accompany each other. The dirtiness scoring of the cows in the two compartments with asphalt can here be viewed in relation to the dirtiness scoring of the cows in the slatted floor compartment here presented as a reference of 100.

4.5 Somatic cell counts

Also the results from the somatic cell count analysis shows that the mastic asphalt “low” compartment has the highest values (see fig 5). Although the somatic cell count depends on many things besides the hygiene in the housing area the results point out that the cows in the “high” compartment had the lowest somatic cell counts. It was presumed that the cows were cleaned equally before milking, but during the time they spend in the cubicles between the two milking occasions they are exposed to different levels of hygiene and this affects the somatic cell count.

The p-values show statistical significance for the factor lactation number, a tendency for cubicle curb height and a weak tendency for factor floor type (see table 4).

Table 4. The somatic cell counts (10 000 per ml) of the cows from each compartment and p-values from the statistical analysis.

	Mastic Asphalt (Low)	Mastic asphalt (High)	Slatted floor (Low)	Prob. value at factor floor type	Prob. value at factor cubicle curb height	Prob. value at factor lactation
Cell count, 10^4 per ml	9.2 ± 17.2	6.4 ± 11.4	7.7 ± 7.1	0.147	0.093	0.019

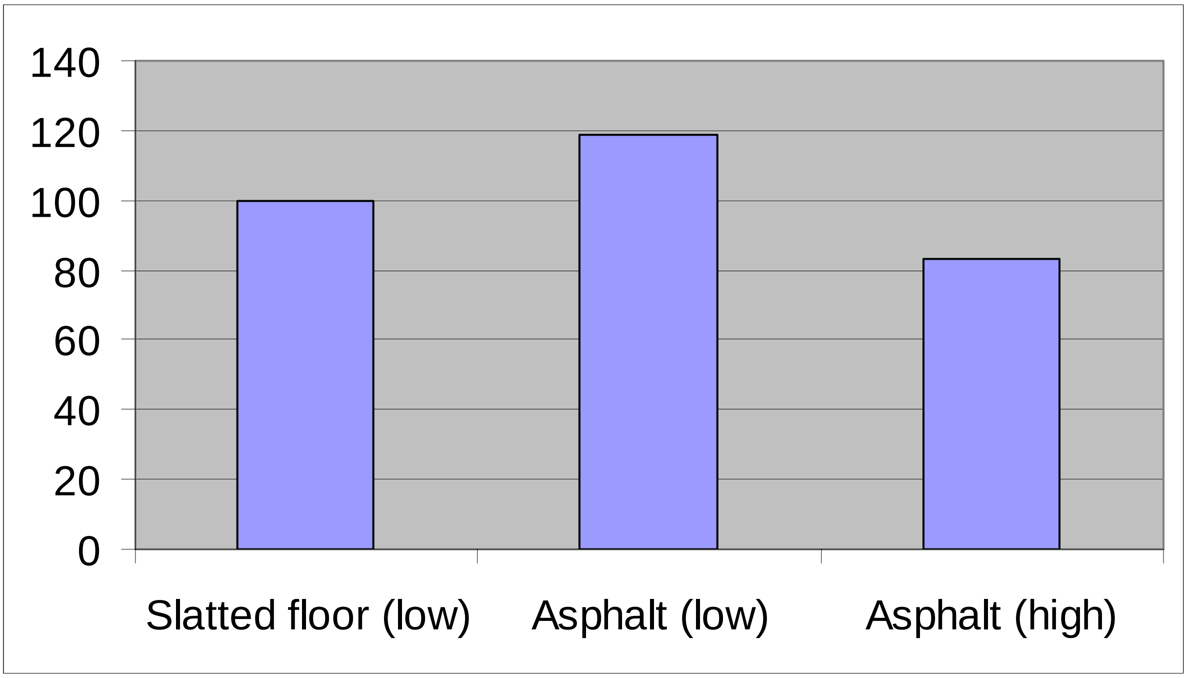

Figure 5. The figure shows the results from the somatic cell count analyzis. The cell count of the cows in the two compartments with asphalt can here be wieved in relation to the cell count of the cows in the slatted floor compartment here presented as a referens of 100.

4.6 Conclusions

The results from the different examinations all point out that the mastic asphalt compartment with high-situated cubicles has the best hygiene. The amount of manure were lower than in the other compartments, the number of bacteria were lower, the cows were cleaner on their udder and teats and the somatic cell count were lower among the cows in this compartment compared to the other cows. This result agrees with my hypothesis and confirms the idea that the cubicles height over the floor has an impact on the hygiene for the cows. The statistical analyses for factor cubicle curb height show statistical significance in both the cubicle manure contamination examination, the coliform bacterial analysis and in the udder and teat hygiene examination. In the somatic cell count analysis the p-values for factor cubicle curb height show a tendency that the model is correct. In this analysis the use of a larger sample selection could establish the model used even more and could lead to more reliable results. When it comes to the statistical analysis of the somatic cell counts, there would be a good idea to go further and examine the changes in somatic cell count after the cows where place in each group since it is the change in cell count that is interesting as the cow acclimatize to it's new environment.

All results except the cubicle manure contamination analysis point out that the mastic asphalt compartment with low cubicles is the one with the most poorly hygiene. The cubicle manure contamination analysis shows that the slatted floor compartment had the most poorly hygiene. My hypothesis was that when comparing the solid floor compartments with scrapes to the slatted floor compartment the first mentioned should be easier to keep clean and should therefore have a better hygiene. The results now point out that when the cubicles are as low as 10 cm the slatted floor compartment is easier to keep clean than the compartment with solid floor and scrapes. One explanation for this could be that the cows in the mastic asphalt "low" compartment are milked last in the group of 100 cows. This means that they spend more time before milking in the area where the cubicles are compared to the other groups. They therefore have more time to make the cubicles dirty and since they alter in standing or lying down position they will be dirtier. There are however need for more studies in this area and for more large-scale studies that extend over a longer period of time and that consist of more background data.

The statistical analyses for factor floor type only show statistical significance for percent manure in the cubicle manure contamination analysis and for the udder and teat hygiene examinations. There is also a weak tendency for factor floor type in the somatic cell count analysis. These results show that the floor type is of less importance when it comes to hygiene than cubicle curb height is that showed significance for more parameters and greater tendencies. The factor lactation numbers showed statistical significance in both the udder and teat examinations and in the somatic cell count analysis. This is however not surprising since cell count is strongly correlated with lactation number and since older cows tend to have more hanging udder and are therefore more prone to dirty there udders and teats.

From these results some general advices can be given. The results strongly point out that high-situated cubicles are cleaner than lower situated cubicles. However, there must be a limit of how high they should be, i.e. an optimal height. To high cubicles can result in difficulties for older cows when they should get up to the lying area. Cows with hanging udders can be dirtier if their udder touches the edge of the high situated cubicle. These are things to take into consideration when planning the building of a new cowshed.

To give recommendations of the floor system that should be used is more difficult when using the results in this project. There are needs for more and wider examinations to do this.

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