The effect of different bedding materials used on free-stalls on dairy cows' preferences

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SUMMARY

This study aimed at investigating cows' preference for five different bedding materials, namely hard rubber mat (HRM), tartan rubber mat (TRM), soft curly mat (SCM), soft foam mat (SFM), and concrete (C). The study was conducted in a free-stall dairy cattle farm housing 50 lactating Holstein cows with access to ten cubicles per each bedding material in four 40-day replicates through a 6 month period. Cow behavior was video recorded for 24 h a day using two cameras to gather information on the number of cows using each free-stall. Results of the study showed the most preferred bedding materials are soft curly mat with 13.54 cows/day and soft foam mat with 13.02 cows/day. Also, the least preferred bedding material is concrete with 3.98 cows/day. In conclusion, soft curly mat can be used as a bedding material on free-stall surfaces instead of concrete because easy to clean, re-bedded. In addition, although the soft foam mats was the second most prefered bedding materials by the cows, it is not recommended to use as a bedding material on free-stall surfaces because of short service-life and easily deformed.

KEY WORDS

Cow preference, concrete, curly mats, rubber mats, tartan rubber.

INTRODUCTION

An environment in which dairy cows can be comfortable is important both in animal welfare and economically. The comfort of free-stalls depends on the type, quality and dimensions of the bedding material. The bedding material should provide the thermal comfort and softness, be also durable and has sufficient friction to allow rising and lying down without slipping. Bedding material should also help in keeping cows clean and healthy while minimizing daily labor requirements[1]. Cows prefer softer bedding materials for lying and they spent longer time in lying down on the soft surface compared to the hard surface[2,3].

Lying behavior is a useful criteria to measure free-stall comfort[4]. Cows prefer, and spend more time lying in, well-bedded, soft and dry stalls[1,3]. Cows that spend less time in uncomfortable free-stalls spend more time standing in the Concrete alleyways. This increase the risk of developing claw diseases and injuries[5,6].

Cow comfort is an important component of production and overall health. Stall use can be an indicator of cow preference, and preference can be interpreted as a measure of cow comfort. Improving cow comfort can affect cow's milk yield and productive life, and the overall success of a dairy operation[7].

Cow comfort is also a top priority for dairy farmers and the free-stall resting surface material is a major contributing factor to the comfort of cows. The stall surface must be comfortable enough to attract a cow to lie down in the stall rather than elsewhere[8].

In several studies[9;10;11;12;13;14;15;16] the effect of different bedding materials such as sand, straw, sawdust, soft/hard rubber mats, waterbeds, foam mattresses, cacao bean husk, switchgrass (*Panicum virgatum* L.) and concrete examined in terms of cows behavior and milk yield. However tartan rubber mats and soft curly mats bedding materials used in this study did not test in none of those studies before. These new bedding materials have important features such as easy to clean, cheaper and longer service life.

This study aimed to compare 5 different bedding materials in terms of cow preference. In addition, it examined the relationship between bedding materials and the season (in four 40-day replicates through a 6 month period from July to December). The study also investigated the relationship between bedding materials and application period (morning-noon, noon-evening, evening-night, night-morning) for different application for season (Application 1, Application 2, Application 3, Application 4) and throughout the season.

MATERIAL AND METHOD

Animals and Housing

The study was conducted in a dairy cattle barn located at the Akdeniz University Experimental Research Area of Agricultural Faculty in Antalya. The two-row free-stall barn was a naturally ventilated dairy cattle barn with an east-south orientation and with the curtained north wall. The free-stalls were 110 cm width and 210 cm length with neck rail (110 cm above free-stall surface) and designed to allow space sharing. The floor of barn was concrete (C). Floor of the feeding area was also concrete and automatic scrapers were used to clean the barn. The rearing animals and the dry cows were kept in different section inside the barn. The barn had two padox located in northside

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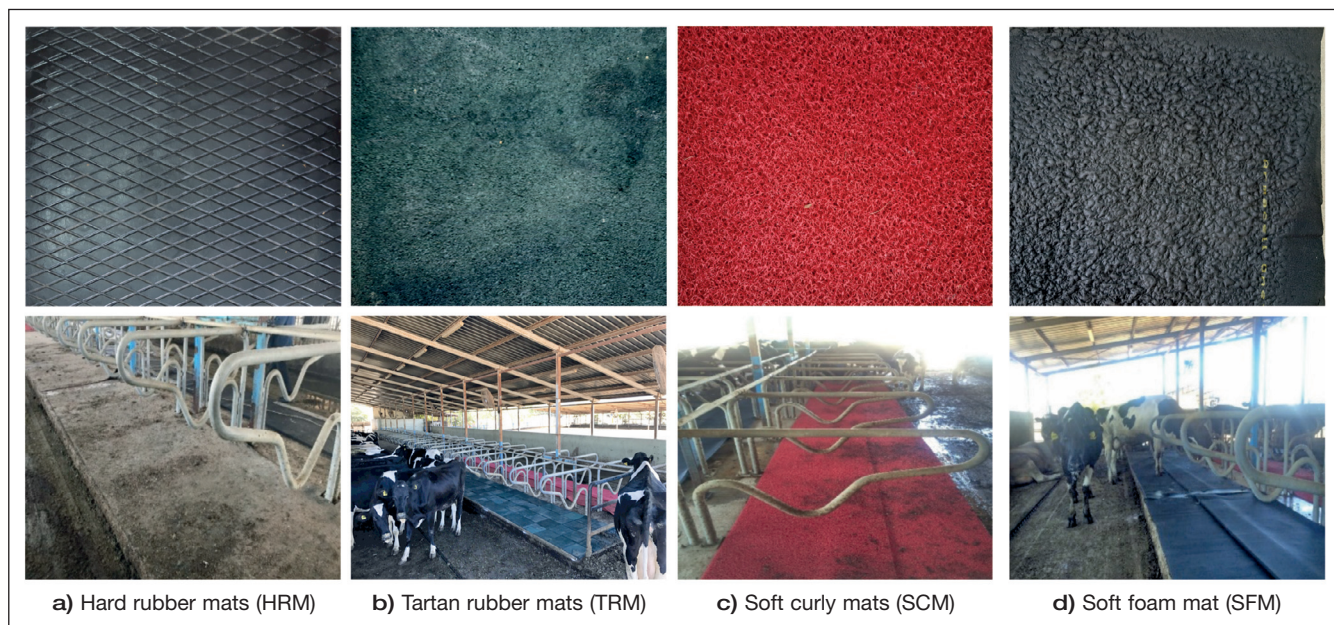Kenan Büyüktaş (kbuyuktas@akdeniz.edu.tr).

| **a)** Hard rubber mats (HRM) | **b)** Tartan rubber mats (TRM) | **c)** Soft curly mats (SCM) | **d)** Soft foam mat (SFM) |

Figure 1 - Bedding materials used in the study.

and southside for cows spend their times freely.

50 lactating Holstein cows (averaging 300 day of lactation) were used in the experiment. Mean body weight of the cows was 650 kg and the average body length (defined as top line length from nose to tail) was 150 cm. During the experimental period, ration consisting of three different feeds made rough feed, concentrate feed and silage feed were given to cows. Each cow consumed an average of 40 kg/day of total mixed ration (9 kg/day rough feed, 6 kg/day concentrate feed and 25 kg/day silage feed) twice a day at 09:00 AM and at 04:00 PM. Cows were milked twice a day (07:00 AM and 07:00 PM) in milking room located in a separate compartment. The average daily milk production of the cow groups was 28 kg before the experiment while it was 28.5 kg during the experiment.

Bedding Materials

Four different bedding materials were tested in the experiment; hard rubber mats (**HRM**), tartan rubber mats (**TRM**), soft curly mats (**SCM**) and soft foam mats (**SFM**) (Figure 1). Each 10 free-stalls in the barn bedded with different bedding materials. Remaining 10 free-stalls having concrete (**C**) floors also chosen as control treatment. Some physical properties belonging to the bedding materials used in the study were given in Table 1.

Cow Behaviors

Two cameras (Lg LCU5500R 700 TVl 2.8/12 mm) recorded 24 h/d of cow behaviors. One camera was placed east side and one camera was placed west side of the barn for a complete view. The cameras were attached to a video multiplexer and time-lapse recorder. Night video recording was facilitated due to the fact that it was the night vision feature in the cameras. Video recordings were scanned at 5-min inter-

Table 1 - Some physical properties belonging to the bedding materials used in the study.

Bedding materials	Dimensions (cm) Width-Length-Thickness	Weight (kg/m²)
Hard rubber mats (**HRM**)	110x200x1.2	9.6
Soft foam mats (**SFM**)	110x200x3.2	1.2
Soft curly mats (**SCM**)	110x200x1.4	4
Tartan rubber mats (**TRM**)	110x200x3.0	20

vals; during each scan, it was recorded the general activity patterns of each cow on all recorded days. This activity was number of cows using in each free-stalls. This sampling method determined the number of cows used the free-stalls having different bedding materials.

Experimental Design

The study carried out in a 6 months period between June 2016 and December 2016. The experiment conducted with four replications with 40 days intervals to investigate the effect of season beside the free-stall preference of the cows (Table 2). Additionally, the cameras were monitored continuously and the data were recorded by dividing the day into 4 time periods (6 hour intervals) to be able to determine the effect of time (Table 2). Each bedding materials except soft foam mats used in the experiment was removed and cleaned at the end of each application. Soft foam mats were removed and did not use in the new replications again because they

Table 2 - Application date and times of application periods of bedding materials.

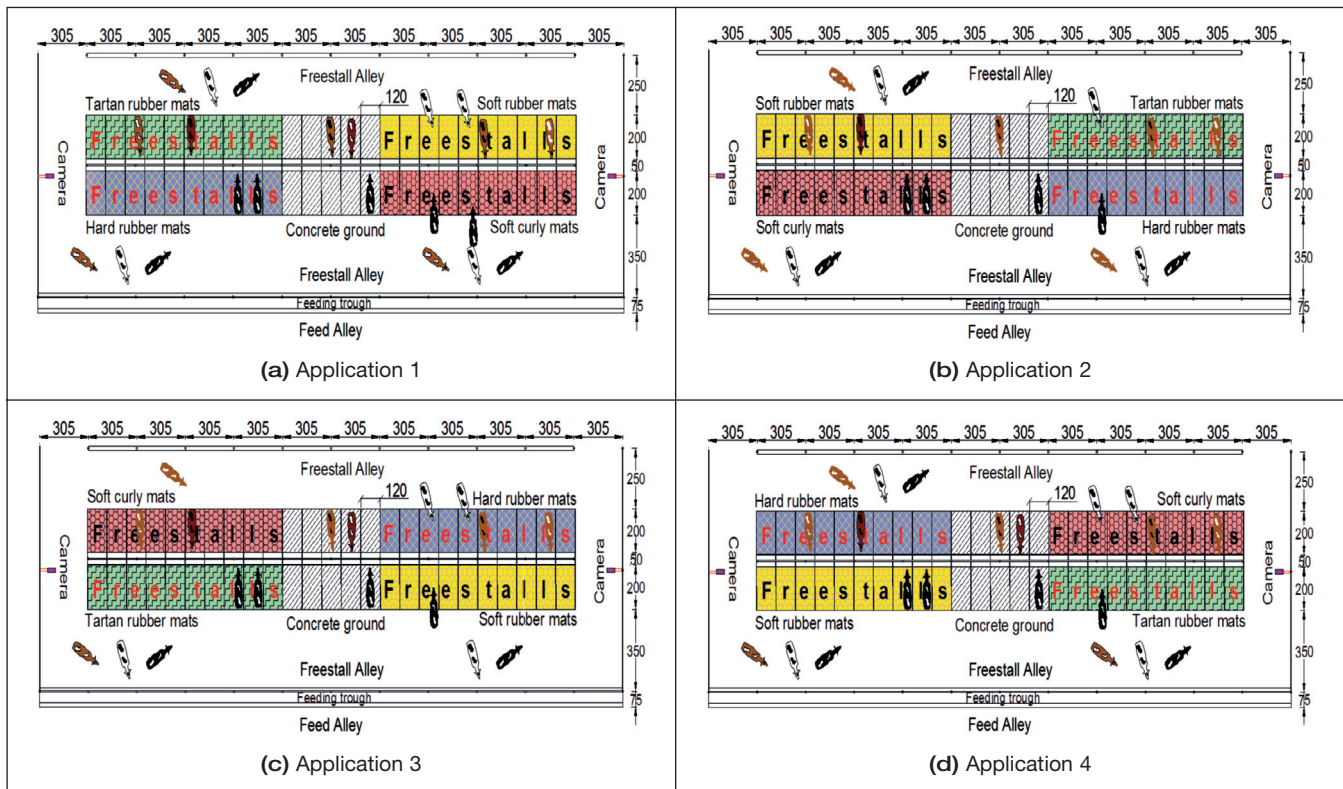| Applications	Date	Application Periods		Times
Application 1	July 1st - August 9th 2016	Morning - Noon	(M-N)	06:00 - 12:00
Application 2	August 14th - September 22th 2016	Noon - Evening	(N-E)	12:00 - 18:00
Application 3	September 27th - November 5th 2016	Evening - Night	(E-N)	18:00 - 00:00
Application 4	November 10th - December 19th 2016	Night - Morning	(N-M)	00:00 - 06:00

Figure 2 - Experimental designs in different application periods.

were very damaged. New soft foam mats were also re-bedded to free-stalls in each application.

Each bedding material was bedded in four different locations on the free-stall surfaces provided that concrete floor remains fixed. Four different applications were conducted during the 6 months and the number of cow which was preferred the free-stalls were determined (Figure 2). The bedding materials located randomly in four different applications.

Climatic Conditions

Temperature and relative humidity data outside and inside the barn were measured during the experiment. Outside climatic data were taken from the meteorological station next to the barn. Inside climatic data were recorded with three data loggers (TESTO 175-H1 temperature and relative humidity data loggers, -20 to +55°C temperature and 0-100% humidity measurement range) which were placed to different points and heights in the barn. Data loggers recorded temperature and relative humidity values in every minute during the experiment. Measurments were taken during 6 months in total including 3 different seasons (summer, autumn and winter) between 1st July 2016 and 19rd December 2016. Thus, it was investigated in which season the cows prefer the bedding materials more.

Statistical Analysis

The statistical model included the effects of mat, day period and application. Post hoc pairwise comparisons were performed using Duncan's Multiple Range Test. Correlations between bedding materials and the season (in four 40-day replicates through a 6 month period from July to December) and bedding materials and application period (morning-noon, noon-evening, evening-night, night-morning) for different application for season (Application 1, Application 2,

Application 3, Application 4) and throughout the season were performed using Statistical Analysis Software (SAS 9.2) at $P < 0.05$ significance level.

RESULTS

Bedding Materials

The number of cows preferred different bedding materials in different time periods of the day are given in Table 3. It was found out that there is a statistical difference at $P<0.01$ significance level between bedding materials, application periods and their interactions. During the 6-months period which included all the application periods, bedding materials preferred by the most number of cow were SCM and SFM with the 3.38 cows/day and 3.26 cows/day, respectively. C was preferred by the least number of cow with 0.99 cows/day. Cows prefer softer bedding materials for lying and they spent longer time in lying down on the soft surface compared to the hard surface[2,3]. Our results were compatible with these literatures. Besides, it was observed that the cows preferred the free-stalls at the most Noon-Evening time period with an average of 5.27 cows/day (Table 3).

Season

The average minimum and maximum temperatures were 27.9°C and 33.3°C for the Application 1, 23.6°C and 31.2°C for the Application 2, 16.1°C and 25.9°C for the Application 3 and 8.6°C and 22.3°C for the Application 4, respectively (Figure 3). Temperature and relative humidity values inside the barn showed parallelism with the values outside the barn (Figure 3 and Figure 4).

THI values are criteria used to determine the severity of heat stress in dairy cattle. Heat stress begins when this value is

Table 3 - Least square means of cows observed using different bedding material in different time periods of the day throughout the season.

Bedding material type	Application periods				P > F	Bedding Mat. Type Average
	Morning-Noon	Noon-Evening	Evening-Night	Night-Morning		
Hard rubber mats (HRM)	2.62 B£b^ψ	6.48 Aa	1.64 Ca	0.83 Db	***	2.89 b
Soft foam mats (SFM)	3.24 Bb	6.51 Aa	1.68 Ca	1.59 Ca	***	3.26 ab
Soft curly mats (SCM)	5.08 Ba	6.47 Aa	1.40 Ca	0.59 Cb	***	3.38 a
Tartan rubber mats (TRM)	3.19 Bb	4.85 Ab	0.73 Cb	0.49 Cbc	***	2.31 c
Concrete (C)	1.29 Bc	2.04 Ac	0.43 Cb	0.23 Cc	***	0.99 d
P > F	***	***	***	***		
Application periods average	3.08 B	5.27 A	1.17 C	0.75 D		
Importance level	Bedding material type (MT): ***		Application period (AP): ***		MT x AP: **	

£: In the section written in italics; the capital letters show comparison of the averages given along the horizontal (along the row) at the P<0.05 significance level according to the Duncan test.

ψ: In the section written bold, the small letters given in vertical (along the column) and the capital letters given in horizontal (along the row) show comparison of the averages at the P<0.05 significance level according to the Duncan test.

*, **, *** P<0.05, P<0.01, P<0.001 it is important at the level of probability, respectively.

ns: not significant.

Footnote: Morning-Noon (M-N): Between 06:00 and 12:00 AM   Noon-Evening (N-E): Between 12:00 and 18:00 PM
Evening-Night (E-N): Between 18:00 and 00:00 PM   Night-Morning (N-M): Between 00:00 and 06:00 AM
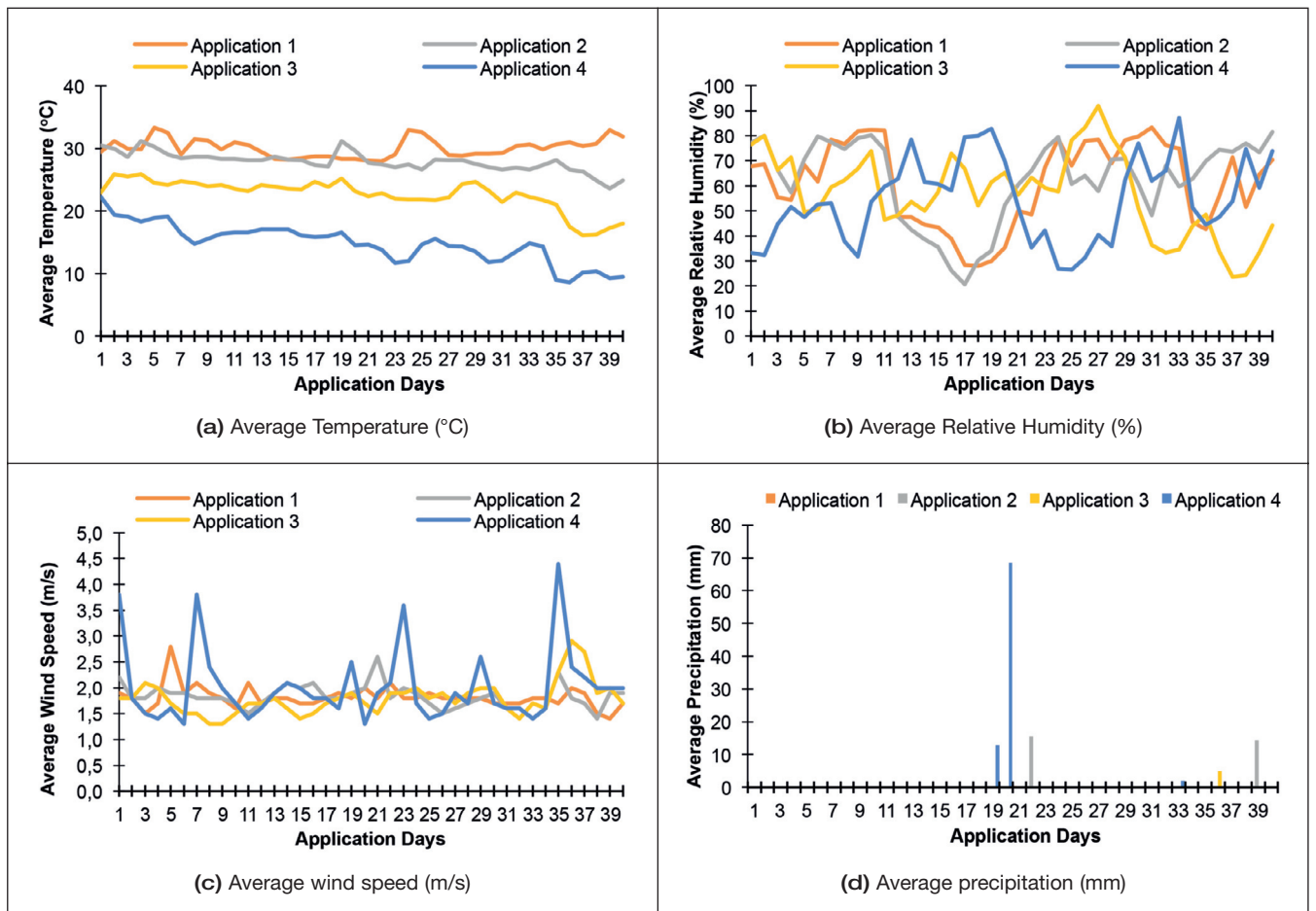

Figure 3 - Outside climatic parameters recorded during the study for each application.

over the 72 and the cows tend to spend more time outside the barn. The highest THI values were determined in Application 1 and the lowest THI values were determined in Application 4 in the study (Figure 5). According to Smid et al., 2018[9] weather conditions (relative humidity, air temperature, wind speed, precipitation, and THI) never had a significant effect on the amount of time cows spent outside. So, there is no good corelation between THI and bedding material preference.

In the study, there was a relationship between season effect and free-stall usage. The number of cows using in the stalls were greater in the on cold days (Application 4) than on the hot days (Application 1-2) and the cows spent less time outside of the stall in on cold days (Table 4). It is likely under-
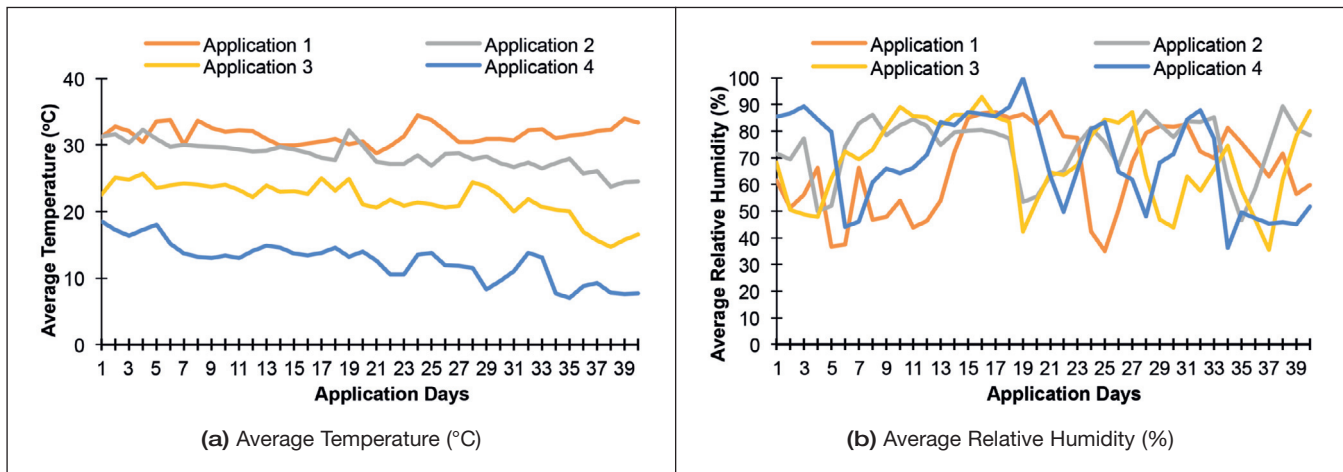
Figure 4 - Inside climatic parameters recorded during the study for each application.
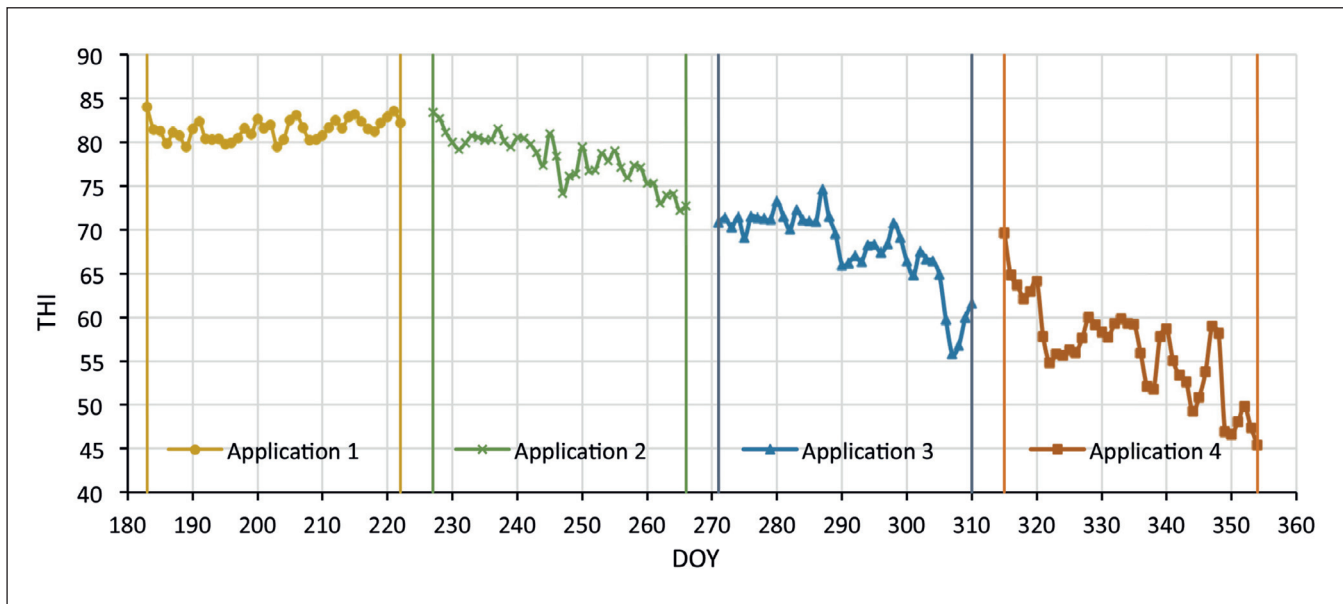

Figure 5 - THI values for different application periods.

Table 4 - Least square means of cows observed using different bedding material in different time applications of the season.

Bedding material type	Applications				P > F	Bedding Mat. Type Average
	Application 1	Application 2	Application 3	Application 4		
Hard rubber mats (HRM)	10.55 $B^{£}b^{ψ}$	9.45 Ba	14.50 Aa	11.78 ABc	*	11.57 b
Soft foam mats (SFM)	13.28 Bb	9.05 Ca	7.65 Cb	22.10 Aa	***	13.02 a
Soft curly mats (SCM)	18.35 Aa	11.15 Ba	8.03 Bb	16.63 Ab	***	13.54 a
Tartan rubber mats (TRM)	6.00 Cc	8.83 Ba	5.63 Cc	16.55 Ab	***	9.25 c
Concrete (C)	5.85 Ac	3.90 Ab	1.88 Bd	4.285 Ad	***	3.98 d
P > F	***	***	***	***		
Application periods average	10.81 B	8.48 C	7.54 C	14.27 A		
Importance level	Bedding material type (MT): ***		Application period (AP): ***		MT x AP: **	

£: In the section written in italics; the capital letters show comparison of the averages given along the horizontal (along the row) at the P<0.05 significance level according to the Duncan test.
ψ: *In the section written bold, the small letters given in vertical (along the column)* and the capital letters given in horizontal (along the row) show comparison of the averages at the P<0.05 significance level according to the Duncan test.
*, **, *** P<0.05, P<0.01, P<0.001 it is important at the level of probability, respectively.
ns: not significant.

stood that there was effect of temperature on the number of cows using free-stalls within either winter or summer. While THI values of Application 1 were higher than Application 4, the average number of cows that preferred the free stalls in Application 1 was lower than Application 4 (Table 4 and Figure 5). Besides, there were effects of different time periods of day on number of the cows using the free-stalls during the season. The number of cows using the stalls were more in Morning-Noon and Noon-Evening time periods than Evening-Night and Night-Morning time periods (Table 3), but cows were feeding in Morning-Noon and Noon-Evening time periods. As the weather getting darkness during the season, cows tended to spend less time lying down.

The more cows spent time mainly on SCM rather than HRM, SFM, TRM and C in Application 1. HRM, SFM, SCM and TRM bedding materials were preferred by more cows rather than C in Application 2. HRM and SFM bedding materials were preferred by more cows in Application 3 and 4, respectively (Table 4). In Noon-Evening time period in all applications, the reason that higher number of cows preferred the bedding materials is that cows prefer to be inside the barn because of high outside temperature. Moreover, it is thought that cows used the bedding materials more for this reason. Number of cows used free-stalls showed changes by the seasons. More cows used the free-stalls in winter than summer seasons. This can be explained that cows were effected by negative weather conditions.

DISCUSSION

Cow comfort is also a top priority for dairy farmers and the free-stall resting surface material is a major contributing factor to the comfort of cows. The stall surface must be comfortable enough to attract a cow to lie down in the stall rather than elsewhere[8]. Results obtained from this study confirmed that soft bedding materials such as Soft Curly Mats (SCM) and Soft Foam Mats (SFM) were the most preferred beddings by the cows rather than hard bedding materials and support previous studies[10,11]. SCM was the most preferred bedding material with average 4.56 cow in Application 1. The least preferred bedding material was the C with 1.46 cows in Application 1 also and these results were similar to the results of Norring et al., 2010[9], who showed that cows preferred lying down more often on rubber mats than in concrete stalls. SCM, HRM, SFM and TRM bedding materials were preferred by greater number of cows rather than concrete in Application 2. However, there were not any statistically differences between HRM, SFM, SCM and TRM bedding materials in this application. Cows spent the most time standing and lying in the HRM in Application 3 and in the SFM in Application 4. When the average values of the applications were examined, the most preferred bedding material by cows was SCM and SFM and the least preferred one was C. Norring et al., 2010[9] found that the total duration of lying down in the free-stalls was higher on the rubber mat compared with concrete or sand. In the preference test comparing rubber mats and concrete stalls, cows were observed lying down more often on rubber mats than in concrete stalls (73 vs. 18 observations per day, interquartile range: 27 vs. 12). Haley et al., 2001[17] found that cows increased their lying time by 18% compared to the time spent lying on concrete

flooring. Calamari et al., 2009[19] also found that the total number of lying cows per day was greater (P<0.001) on sand (SA) and straw bedded (ST) than on rubber mat (RM) and mattress (MA), but there were no differences in the duration of lying cows. 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 results of Haley et al., 2001[17]; Calamari et al., 2009[19]; Norring et al., 2010[9] support the results of this study.

Comparing all applications to the each other are graphed in order to be able to make comments in a more detailed way (Figure 6). Findings obtained from this study indicated that cows spent the most time in stalls in the Noon-Evening time periods in all Applications. Büyüktaş et al., 2017[20] compared soft rubber mats with hard rubber mats bedding materials and found that cows spent more time lying down or stood up in soft rubber mats (P<0.001) in Noon-Evening time period of day. Our results were similar to the study by Büyüktaş et al., 2017[20].

In Figure 6a, SCM, TRM and HRM bedding materials in Morning-Noon time periods, SCM bedding material in Noon-Evening time period, SCM, SFM and HRM bedding materials in Evening-Night time period, SFM and TRM bedding materials in Night-Morning time period were preferred by the greatest number of cows. Besides, free-stalls were used by the most number of cow in the Noon-Evening time period, while the least number of cow preferred to use free-stall in the Night-Morning time period. This can be explained by the fact that during the Noon-Evening time period, the cows preferred to stay inside the barn because of the high outside temperature. Thus, they used bedding materials more. In the same way during the Night-Morning time period, it is thought that cows preferred to padox due to lower outside temperature.

In Figure 6b, the greatest number of cows preferred the lying down and stood up in free-stall in Noon-Evening time period. In this application period, SFM and SCM bedding materials in Morning-Noon time period, TRM and HRM bedding materials in Noon-Evening time period, SFM bedding material in Night-Morning time period were preferred by the greatest number of cows. However, there was not any statistically difference between the numbers of cows preferring bedding materials during Evening-Night time period.

In Figure 6c, it is seen that SCM in Morning-Noon, HRM in Noon-Evening, HRM, SCM, TRM in Evening-Night and SCM, TRM, HRM in Night-Morning were preferred by the greatest number of cows. Besides this, the greatest number of cows preferred to free-stalls in Noon-Evening time period.

In Figure 6d, as it is to be in all other application periods, free-stalls were preferred by the greatest number of cows in Noon-Evening time period. In this application period, TRM, SFM, SCM in Morning-Noon, SFM, SCM, TRM in Noon-Evening, SFM, HRM in Evening-Night and SFM in Night-Morning were the bedding materials preferred by the greatest number of cows.

Bedding material should help in keeping cows clean and healthy while minimizing daily labor requirements[1]. In all application periods cows tended to lying down and standing up on the soft bedding materials. Soft curly mats (SCM) was the most preferred bedding material by cows. Soft curly mats is the most suitable bedding material because of easy to clean, easy to re-bedded. So, it keeps cows clean and healthy with it's
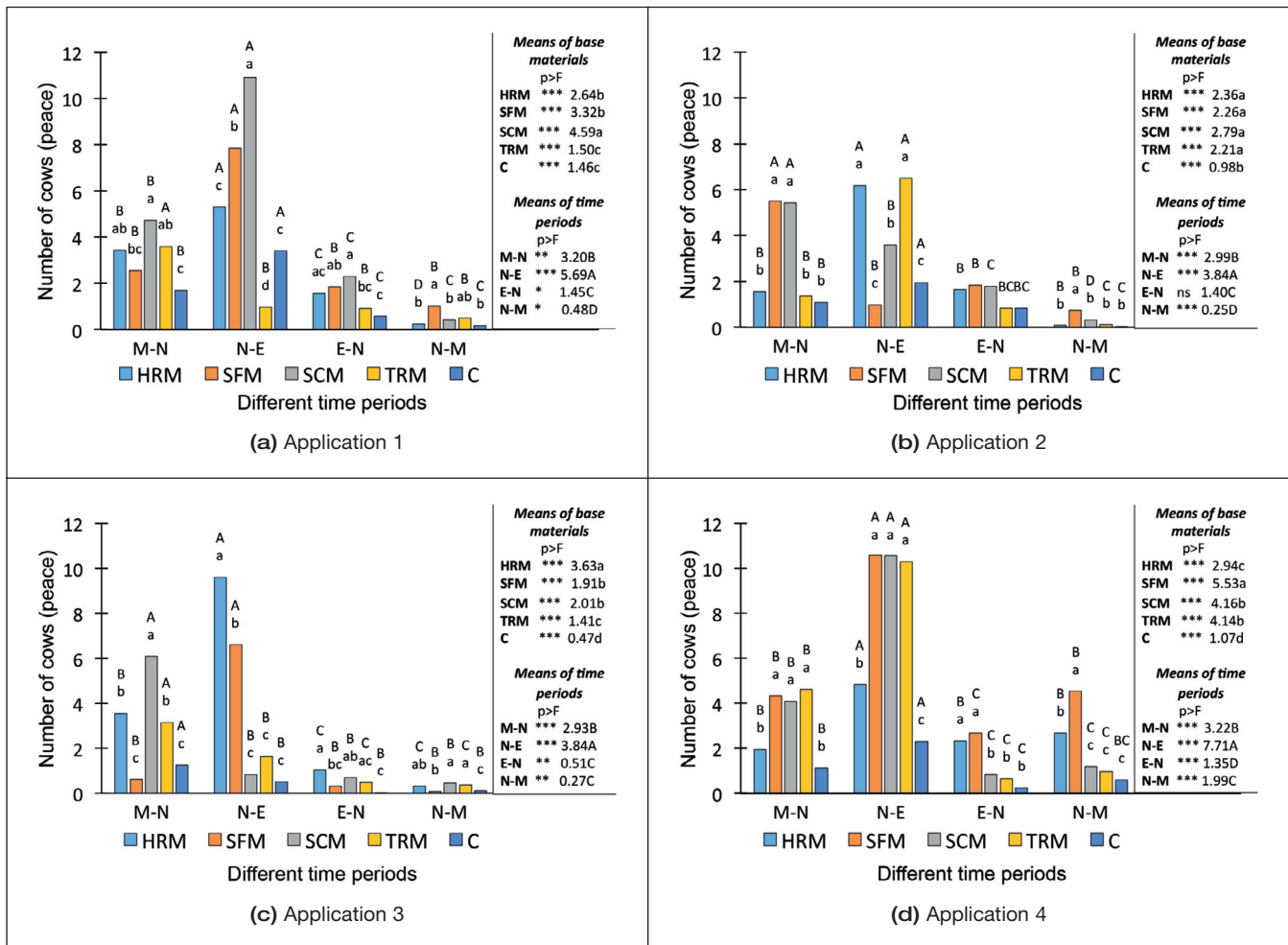
Morning-Noon (M-N): Between 06:00 and 12:00 AM   Noon-Evening (N-E): Between 12:00 and 18:00 PM
Evening-Night (E-N): Between 18:00 and 00:00 PM   Night-Morning (N-M): Between 00:00 and 06:00 AM

➤ The capital letters above the bars show comparison of the averages of same bedding material in each time period at the P<0.05 significance level according to the Duncan test.
➤ The small letters above the bars show comparison of the averages of different bedding materials in same time period at the P<0.05 significance level according to the Duncan test.
➤ *, **, *** P<0.05, P<0.01, P<0.001 it is important at the level of probability, respectively.
ns: not significant.

Figure 6 - Number of cows preferring different bedding materials for different application periods at different time periods of the day.

this aspect. Concrete (C) was the least preferred bedding material by cows. In addition, hard rubber mats, soft curly mats and tartan rubber mats are long lasting bedding materials and they are reusable. Bedding materials used in the study can be classified from cheap to expensive as SFM, SCM, TRM and HRM, respectively. However, SFM is not suitable as bedding material because of easily deformed despite it is the cheapest bedding material. But the other bedding materials play positive role because they are not change at frequent intervals, could be cleaned a lot, could be bedded easily.
Previous studies has shown that cows lay down longer on softer surfaces[3;15;17;19;20].

CONCLUSION

Our results showed that cows tended to use free-stall more on cold days. This is thought to be caused by strong winds and rainfall outside the barn on cold days and high temperature and humidity inside the barn on hot days. Besides,

cows also tended to prefer free-stalls more on daylight hours during a day. This is likely to be thought that the reason is due to the climatic differences between inside and outside the barn. Cows spent time mainly on the softer surfaces such as soft curly mat and soft foam mat, rather than hard rubber mat, tartan rubber mat, and concrete. However, it was observed that soft foam mat was not suitable for free-stall surface as bedding material because of its lightness and softness. Although cows preferred this soft bedding material, it was observed that this bedding material was not also suitable for long term usage. Because cows threw away it from free-stalls due to its lightness and it was easily deformed. Soft curly mat is suitable to bedded to free-stall surfaces because it is lying easily on the free-stall surface, can be re-used after washing, provide isolation between the concrete surface and cows against hot and cold conditions and having durability. Although different soft materials have tested in terms of cow preferences, soft curly mat has never been tested before. This makes the study important to suggest new bedding material for cow comfort.

Similarly, tartan rubber mats also have never been tested before. However, it is not recommended to use as first option because it was not first choice of cows, it is heavy, hard to lying.

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