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Effect of bedding systems and thermal analysis on milk yield of crossbred dairy cows

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Abstract

The current research was carried out to assess the effect of various bedding material on thermal image analysis and yield of milk in dairy cows. Twenty four crossbred cows at the Cattle farm of the Instructional Livestock Farm Complex, Pookode, Wayanad District in Kerala state formed the group in the present research for one lactation period including three seasons viz., summer (February to May), monsoon (June to September) and post monsoon (October to January). T_1 was the control group in which the cows were maintained on concrete floor with no bedding material. Rubber mats (T_2) and coir pith (T_3) were provided on concrete floor. In T_4 Dried solid manure (DSM) on concrete floor was provided at the rate of 7.5 cm thickness as bedding. Thermal image analysis of the heat generated from the animal body, surface of the floor and roof was recorded. The cows maintained on concrete floors (37.79 ± 0.21 °C) and rubber mats (37.56 ± 0.28 °C) generated significantly higher (P<0.05) amounts of heat followed by those kept on DSM (28.49 ± 0.28 °C) and coir pith (25.46 ± 0.26°C). The floor and roof temperatures were higher during summer and post monsoon and lower in the monsoon season. Daily milk yields from the experimental animals were recorded and analysed. The cows maintained on concrete floor had the lowest overall daily milk yield (8.95 ± 0.22) while the cows on coir pith bedding had the highest yield (9.98 ± 0.30). The cows on DSM and rubber mats had an overall mean milk yield of 9.48 ± 0.22 and 9.26 ± 0.20 kg, respectively. Coir pith and dried solid manure as bedding material could be recommended for use by dairy farmers when compared to rubber mats and concrete floor bedding for improving cow comfort and milk production.

Keywords: *Crossbred cows, bedding systems, thermal imaging, milk yield*

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As per 20th livestock census in 2019, 192.49 million numbers of cattle (ranking second in the world population) are available in India and 93 percent of the cattle population are crossbreds in Kerala. Even though crossbred cows are more vulnerable to disease and climatic stress, they are docile and better producers of milk. Hence good care and welfare and comfortable housing with soft beddings are required. Cow comfort under an intensive management system is economically important as it significantly affects the feed intake of the animal, as well as production and reproduction. The primary consequences of reduction in comfort in dairy cows leads to loss of energy, accompanying stress, consequent reduction in feed intake and milk yield (Praveenkumar *et al*.,2022). The World Organisation for Animal Health (OIE, 2008) has propounded five freedoms in relation to welfare of animals and among these, one is the freedom from physical and thermal discomfort by providing access to shelter and a comfortable resting area. Other mentions in the aforementioned document on this line include the freedom to express normal behavioural patterns by providing sufficient space, proper facilities and the company of other animals of the same kind. Availability, cost, design, comfort, ease of use and reuse are the important factors influencing the selection of suitable bedding material on dairy farms. The most commonly used bedding material in cow housing systems are sawdust, wood shavings and sand (Oliveira *et al*., 2019). Other material, including straw, peanut shells and woodchips (Leso *et al.,* 2020) are commonly used bedding material. The demand for traditional bedding material has driven up prices, pushing farmers to look for alternative bedding material. A complete understanding of the nature of alternative material and their characteristics with regard to their use and handling as bedding material is crucial (Agnew and Leonard, 2013) while making a choice of the same.

During the extraction of coir fibre from coconut husk, a ligno-cellulosic biomass, coir pith is formed. It is a comfortable, suitable and animal friendly bedding material. It is ideal for use as bedding for cows due to innate moisture absorbing quality and soft bed cushioning effects. Cattle housing should be well ventilated regardless of the bedding material used, but particularly so when recycled manure solids are used and along with ventilation, adequate drainage should also be installed to ensure a drier environment that would discourage pathogen growth (Leach *et al.,* 2015). Interest in using recycled manure solids (RMS) as a bedding material for dairy cows has grown among commercial milk producers for most farms. The cost of milk production in the state of Kerala was very high, and the milk price has to be adjusted accordingly so that dairy farming becomes a lucrative livelihood opportunity for poor farmers (Sabin *et al*., 2022). Extensive research has amply proved that the use of bedding materials for dairy cattle improves animal comfort and increases milk production. However, research on the use of various types of bedding material for crossbred dairy cattle is scanty. Since the bedding material has a direct relationship with the welfare of the cows, the present study was undertaken to evaluate the thermal image analysis and milk yield in different bedding systems in crossbred cows.

Materials and methods

The study was carried out at the Cattle farm of the Instructional Livestock Farm Complex, Pookode, Wayanad District in Kerala state, located at 11° 32' 18.5 (North) longitude and 76° 01' 14.15 (East) latitude, at an altitude of 867 m above the mean sea level. The locale of study was endowed with humid climate with maximum rainfall by South West monsoon from June to September and North East monsoon from October to November. The study was carried out for one lactation period of 305 days spread over three different seasons as described by Biya (2011) *viz.,* summer months (Feb-May) (25-35°C), monsoon months (June-Sep) (24-31°C) and post monsoon months (Oct-Jan) (20-30°C). Twenty four crossbred dairy cows in early stage of lactation, between four to six years of age were selected for the study. The animals were divided into four groups with six animals in each group with regard to their average body weight of 270-300 kg in 2nd to 4th parity with milk yield of 8.15 to 11.50 kg as uniformly as possible before the start of experimentation.

The cows were maintained under four bedding systems. The animals were let loose in the shed except during feeding and milking time. Floor space of 13 sq. m and manger space of 1.2 m length and 0.6 m width were provided per cow. Dung was removed manually in the mornings and evenings. Animals were washed outside the shed during the trial period. Animals were fed as per ICAR (2013) standards. Daily concentrate ration was fed at 5.00 AM and 2.00 PM and roughage at 10.00 AM and 3.00 PM. Water was provided *ad libitum*. All the treatment groups including control were housed in East-West oriented sheds in a face-to-face arrangement.

Six experimental animals were maintained in the existing management system, *viz.,* concrete floor without any bedding material (T_1). This group was considered as the control group. Rubber mats on concrete floor of 1.2m × 1.8m × 0.025m area were used for six experimental animals (T_2). All other activities including the feeding regime were followed as per routine practice. The rubber mat used in experiment was 16 mm thick, 6'× 4' in size and weighed 40 kg. Coir pith was provided at the rate of 7.5 cm thickness as bedding (T_3). Dried solid manure was provided at the rate of 7.5 cm thickness as bedding (T_4). The moisture content of the DSM was maintained below 25

Table 1. Mean heat generated from cow body in different bedding systems during different seasons

Treatments (n=6)		At 08.00 AM (Mean ± SE) (°C)				At 01.00 PM (Mean ± SE) (°C)				At 05.00 PM (Mean ± SE) (°C)			
		S	M	PM	S	M	PM	S	M	PM	S	M	PM
T_1	Concrete	38.00 ± 0.33	36.46 ± 0.20	37.67 ± 0.47	37.14 ± 0.21^{a}	37.58 ± 0.33	37.35 ± 0.25	36.06 ± 0.49	37.39± 0.21^{a}	37.93 ± 0.29	37.18 ± 0.19	37.24 ± 0.41	37.77 ± 0.20^{a}
T_2	Rubber mat	38.35 ± 0.46	36.37 ± 0.21	37.86± 0.47	37.36 ± 0.26^{a}	38.39 ± 0.54	37.41± 0.20	37.64 ± 0.39	37.56 ± 0.28^{a}	38.68 ± 0.56	37.12 ± 0.38	37.27 ± 0.36	37.89 ± 0.29^{a}
T_3	Coir pith	25.43 ± 0.63	24.25 ± 0.54	24.72 ± 0.34	25.13 ± 0.29^{c}	26.02 ± 0.49	24.48 ± 0.47	25.87 ± 0.27	25.46± 0.26^{c}	26.15± 0.45	24.84 ± 0.57	25.95 ± 0.27	25.23 ± 0.27^{c}
T_4	DSM	28.03± 0.43	27.06 ± 0.23	27.79 ± 0.52	27.65 ± 0.23^{b}	28.74 ± 0.54	27.39 ± 0.26	28.04 ± 0.64	28.49± 0.28^{b}	28.57 ± 0.51	27.35 ± 0.24	28.16 ± 0.50	28.11 ± 0.24^{b}
Overall (Mean± SE)		32.76± 1.17^{A}	31.02 ± 1.14^{C}	32.13 ± 1.13^{B}	31.39 ± 0.65	31.89 ± 1.16^{A}	31.08 ± 1.15^{C}	31.37 ± 1.14^{B}	32.13± 0.66	32.72 ± 1.2^{A}	31.32 ± 1.20^{C}	31.56 ± 1.16^{B}	31.45 ± 0.68

Means with different superscripts (a-c in rows, A-B in columns) differ significantly (*P*<0.05)

Table 2. Mean daily heat generated from floor and roof during different seasons

Season	Floor surface temp (°C)			Roof surface temp (°C)		
	At 8 AM	At 1 PM	At 5 PM	At 8 AM	At 1 PM	At 5 PM
Summer	26.17 ± 0.37^{a}	27.53 ± 0.35^{a}	26.26 ± 0.34^{a}	41.03 ± 0.47^{a}	42.78 ± 0.53^{a}	41.83 ± 0.33^{a}
Monsoon	23.96 ± 0.37^{c}	24.49 ± 0.40^{c}	24.20 ± 0.37^{c}	37.34 ± 0.40^{c}	37.67 ± 0.41^{c}	37.39 ± 0.41^{c}
Post Monsoon	25.36 ± 0.28^{b}	26.20 ± 0.22^{b}	25.68 ± 0.22^{b}	40.40 ± 0.10^{b}	40.56 ± 0.10^{b}	40.29 ± 0.12^{b}

Means with different superscripts (a-c in rows) differ significantly (*P*<0.01)

Table 3. Mean daily milk yield in different bedding systems during different seasons

Treatments (n=6)		Daily milk yield (Mean± SE) (kg)			
		Summer	Monsoon	Post monsoon	Overall
T_1	Concrete	8.20 ± 0.07	9.31 ± 0.03	9.28 ± 0.03	8.95 ± 0.22^{d}
T_2	Rubber mat	8.23 ± 0.01	10.28 ± 0.03	9.30 ± 0.03	9.26 ± 0.20^{c}
T_3	Coir pith	8.35 ± 0.04	11.28 ± 0.04	10.35 ± 0.03	9.98 ± 0.30^{a}
T_4	DSM	8.28 ± 0.01	10.75 ± 0.03	9.41 ± 0.05	9.48 ± 0.22^{b}
(Mean± SE)		8.26 ± 0.03^{C}	10.66 ± 0.09^{A}	9.52 ± 0.15^{B}	9.34 ± 0.13

Means with different superscripts (a-d in rows, A-C in columns) differ significantly (*P*<0.05) per cent above which the wet material was replaced by dried bedding (Li *et al.,* 2008). Concentrate and green fodder was fed as per the routine schedule. All other activities including the feeding regime were followed as per standard practice.

The coir pith and DSM were sundried and treated with two per cent calcium hydroxide to destroy pathogens and lime was mixed in homogeneously (Gerba and Smith, 2005) before each season of the experiment. Thermal image analysis of the heat generated from animal body, surface of floor and roof was recorded by using an FLIR® infrared camera three times in a day at 8.00 AM, 1.00 PM and 5.00 PM at weekly intervals. Data on daily milk yield (kg) were recorded with respect to all experimental animals both in the morning at 5.30 AM and in the afternoon at 2.30 PM. Two-way ANOVA with interaction effect was performed to study the effect of different bedding material and seasons on milk yield of cows.

Results and discussion

Heat generated from animal body

The overall mean heat generated by the cows managed under different bedding material was recorded three times in a day at, at 8.00 AM, 1.00 PM and 5.00 PM, at weekly intervals. In order to understand the variations in the generation of heat at different time intervals, three separate analyses were performed with the values recorded at three different time intervals as mentioned above and the mean values are furnished in Table 1. The results of two-way ANOVA revealed that the overall mean heat generation from the animals maintained in different bedding material differed with the seasonal variations as the interaction effect was significant (P<0.05). Also, the type of bedding material had significant effect on the amount of heat generated at 1:00 PM. The cows maintained on concrete floor (37.79 ± 0.21) and rubber mat (37.56 ± 0.28) generated significantly higher (P<0.05) amounts of heat followed by DSM (28.49 ± 0.28) and coir pith (25.46 ± 0.26°C).

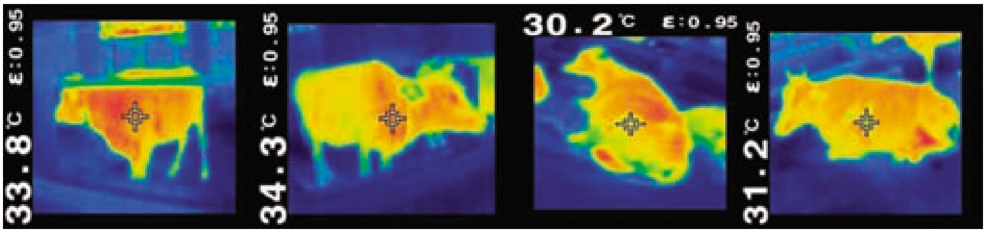
The overall mean heat generated from the body of the cow reared on different bedding systems were in decreasing order from rubber mats, concrete floor, DSM and coir pith at 8:00 AM and 5:00 PM. In general, it was noted that the animals maintained on coir pith and DSM generated comparatively lower body heat while the cows maintained on concrete and rubber mat had higher body heat generation irrespective of the seasons and timing of recording. However, the overall body heat generation at 1.00 PM was significantly higher (P<0.05) than at 8.00 AM and 5.00 PM during summer. The same pattern was found during the monsoon and post monsoon seasons. Thermal images of cow body heat in different seasons, *viz.,* summer, monsoon and post monsoon are depicted in Fig. 1.

This study reiterates the report of Kunc *et al*. (2007) where they mentioned that IRT could be used as a potential non-invasive and non-contact heat-detecting technology and the infrared camera measured the infrared radiation emitted from an object.

Heat generated from floor and roof

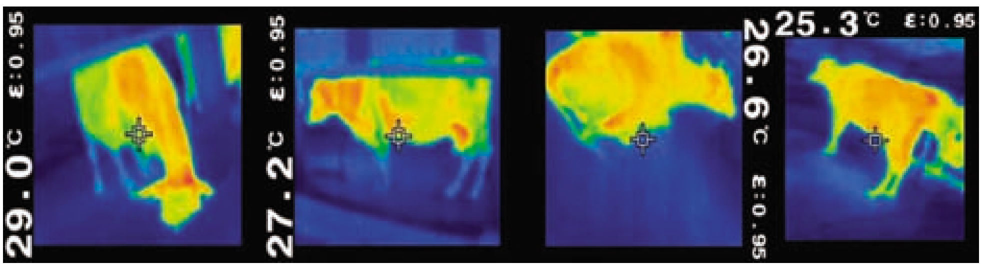
The mean daily heat generated from floor and roof is presented in Table 2. The floor temperature was higher (27.53 ± 0.35) in summer followed by post monsoon (26.20 ± 0.22) and lower in monsoon (24.49 ± 0.40°C) at 1.00 PM with significant difference (P<0.01). Ae similar trend was noted for floor temperature at 8:00 AM and 5:00 PM during the three different seasons. The roof temperature was also higher (42.78 ± 0.53) in summer followed by post monsoon (40.56 ± 0.10) and monsoon (37.67 ± 0.41°C) at 1.00 PM with significant difference (P<0.01). The same pattern was observed in during monsoon and post monsoon at 8:00 AM and 5:00 PM. In general, both the floor and roof showed higher temperature during summer and lower temperature during post monsoon and monsoon.

Knizkova *et al*. (2007) reported temperatures of 27.95 ± 0.15 on the floor and 37.17 ± 0.32°C on the roof of cattle sheds during the summer season than other seasons which concurs with the findings of the present study. They also noted that the effect of weather conditions, circadian and ultradian rhythms, time of feeding, milking, lying and rumination



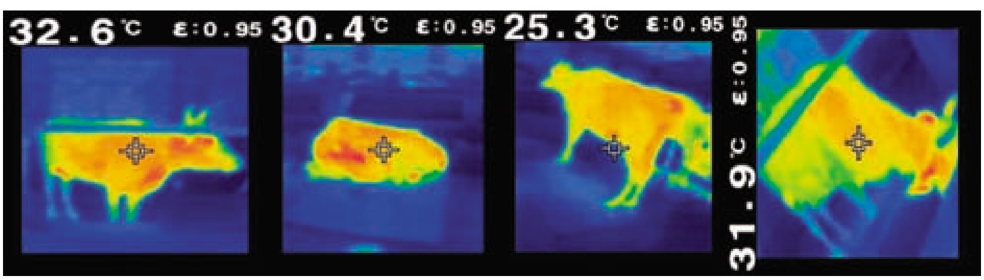
T1-Concrete floor T2-Rubber mats T3 -Coir pith T4 -Dried solid manure

a. Summer



T1-Concrete floor T2-Rubber mats T3 -Coir pith T4 -Dried solid manure

b. Monsoon



T1-Concrete floor T2-Rubber mats T3 -Coir pith T4 -Dried solid manure

c. Post monsoon

Fig. 1. Thermal images of cow body heat in different seasons

etc., needed to be considered along with factors like sunlight, moisture, dirt, weather condition, *etc*., during the measurement of temperature using IRT.

Milk yield

The mean daily milk yield of cows on different bedding material is presented in Table 3. The results revealed that the type of bedding material, season and the interaction between seasons and bedding material significantly altered the mean milk yield of cows (P<0.05). The F-value for the interaction (76.12) and between groups (672.40) and seasons (4066.99) were found to be statistically significant.

The cows maintained on concrete floor had the lowest overall daily milk yield (8.66 ± 0.22) while the cows on coir pith had the highest yield (9.98 ± 0.30). The cows on DSM and rubber mats had the overall mean milk yield of 9.48 ± 0.22 and 9.26 ± 0.20 kg, respectively. The per cent increase in milk yield was 12.14 in cows maintained on concrete floor, which served as the control group followed by 15.33 on rubber mat, 17.21 on DSM and 19.50 on coir pith bedding. Before the start of trial, the overall mean milk yield was 8.24 ± 0.05, 8.25 ± 0.04, 8.27 ± 0.02 and 8.26 ± 0.06 for cows reared on concrete floor, rubber mats, coir pith and DSM bedding systems.

The results of Kremer *et al*. (2007) as they reported greater activity and better overall milk yield of high-yielding dairy cows which were on elastic rubber mats (9.28 ± 0.12) than that on concrete floor (8.68 ± 0.12 kg) in a loose housing system was complementary to the present study. The findings of Singla *et* *al*. (2007) are in agreement with this study, as they reported mean milk yield of 11.27, 10.56, 9.82 and 9.55 L/animal/d in herds provided with paddy straw bedding material and 11.34, 10.32, 9.31 and 9.26 L/animal/d in coir pith bedding in depth of 30 cm, 20 cm, 10 cm on concrete floor and in the present study bedding material of 7.5 cm thickness was provided.

From Table 3. it may also be noted that the mean milk yield of cows maintained on different bedding materials was also influenced by the seasonal variations as the differences of overall means of milk yield during different seasons within the cow groups were statistically significant (P<0.05). Moreover, the mean values for different seasons ranged from 8.26 ± 0.03 kg in summer to 10.66 ± 0.09kg in monsoon. The results are in agreement to Barberg *et al*. (2007) as they noted increase in milk production of 9.57 ±0.12 kg in compost bedded pack than bedded with dry fine wood shavings or sawdust (9.76 ± 0.03 kg). Singh *et al*. (2015) obtained the average highest seasonal milk production of 10.52 ± 0.12 and 9.54 ± 0.14 kg in crossbred during winter and summer season, respectively with highly significant difference (P<0.05) in seasonal variation and milk production performance which coincides with the present study.

Conclusion

In the present study, the cows maintained on concrete floor (37.79 ± 0.21) and rubber mat (37.56 ± 0.28) generated significantly higher (P<0.05) amounts of heat followed by DSM (28.49 ± 0.28) and coir pith (25.46 ± 0.26°C). The cows maintained on concrete floor had the lowest overall daily milk yield (8.95 ± 0.22) while the cows on coir pith had the highest yield (9.98 ± 0.30 kg). Thus, coir pith and dried solid manure as bedding material could be recommended to dairy farmers when compared to rubber mats and concrete floor for improving cow comfort and milk production.

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Conflict of interest

The authors declare that they have no conflict of interest.

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