Effect of Milking Environment Enrichment Through Music on Production Performance and Behaviour in Cattle

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Research Article

Keywords: Cortisol, Environment enrichment, Milk yield, Milk let down, Music, Stress

Posted Date: January 12th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1180327/v1>

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Abstract

Enrichment of milking environment through music has been proposed to help animals to cope with divergent stressors. This study aimed at evaluating the effect of Indian instrumental music-based environmental enrichment on milk production performance and behaviour in cattle. A total of 21 lactating dairy cattle (*Vrindavani* crossbred cows) having similar parity and stage of lactation were selected in three groups – T1, T2, and T3 each consisting of seven animals. The T1 and T2 groups were exposed to instrumental flute and sitar respectively 10 minutes prior to the start of milking and continued till completion of milking; while the T3 group served as control. Musical enrichment of the environment was done using recorded-tape of flute and / sitar was played in *yamen raga* at 40-60 decibels intensity. The results revealed a non-significant difference in milk yield, rectal temperature, respiration rate, T3 and T4 hormones. However, there exhibited a significant ($p<0.05$) difference in milking time, milking speed, cortisol hormones and behavioural parameters such as milk let down in the animals exposed to music compared to the control group. Thus, the results have significant implications relating to the behavioural fitness and welfare of dairy animals and reducing residual milk.

Introduction

Dairy farming globally is changing towards an intensive production system where expressing animals' natural behaviour is impaired. High-yielding dairy animals are often under production stress. The environment in milking barns and the experience of rough handling of animals by milkers during the milking process cause stress in animals. Due to the bad experiences faced by animals in milking parlours, the animals hesitate to enter the milking barns. The sound of human shouting and metal items slamming increases the heart rate and activity of cattle (Waynert et al., 1999). Under increasing stress conditions, dairy cows show declined milk production. For both ethical and physiological concerns, chronic stress and anxiety are undesirable. Stress in animals produces not only immediate reactions, but it can also have long-term effects on their biology, even across generations (Ericsson et al 2016). Stress can potentially inhibit the release of oxytocin - a key hormone responsible for releasing of milk in animals. Thus, under stress-prone environmental circumstances, introduction of enriching amendments could induce a significant improvement physiology of animals (Newberry 1995). Environment enrichment also help animals to cope up with stressors in their surroundings, reduce frustration, increase the fulfilment of behavioural needs, and promote more positive affective states (Mandel et al, 2016). An efficient management of the surrounding environment thus plays an important role towards maximising profitability, animal comfort and welfare. In this context, many farmers and dairy owners have employed various strategies and new technologies to improve milk yield and animal comfort; however, the success is limited. Playing classical music inside the milking parlour has an indirect impact on cow welfare, because it reduces ambient noise for cows (Cloutier, 2000; Mandel et al 2016). Music has been shown to exhibit a mood-regulatory effect (Saarikallio and Erkkila, 2007). A calming music can improve milk yield, probably due to its role in decreasing the stress levels. Slow music is reported to improve daily milk yield by 3% in cows, while fast music decreases it by 2% (Nold 2007). Wells (2009) reported classical and country music to have more positive effects on behavior than rock music increasing stress. Playing music might be a practical tool to reduce necessary efforts of driving cows to milking (Lemcke et al 2021) and also reported that the music genres exhibited different responses on milk yield in different trails by various researchers, might be due to other characteristics of the music, such as different frequencies (measured in hertz, Hz), tempi (measured in beats per minute, bpm), or amplitudes (measured in deci-bel, dB). Thus, an optimization of musical enrichment of the milking environment of dairy animals is critically needed to maintain an optimal balance of the animal comfort, behavioural needs, and reducing residual milk. This study typically evaluates the influence of different Indian classical instrumental music on stress levels in animals, milk production, and animal comfort and welfare.

Experimental Design

The study was conducted on lactating dairy animals at the Cattle and Buffalo (C&B) Farm of Indian veterinary Research Institute, Izatnagar, Uttar Pradesh, India. The experimental site is located at an altitude of 169 meters above mean sea level; 28.22⁰N, 79.24⁰ E. A total of 21 lactating dairy cattle (*Vrindavani* crossbred cows) having similar parity and stage of lactation were selected in three groups – T1, T2, and T3 each consisting of seven animals. Music system was installed in milking barn. The speakers were placed at one-meter height in front of animals and all the (instrument) music was played in *yamen raga* at 40-60 decibels intensity. The T1 and T2 groups were exposed to instrumental flute and sitar respectively 10 minutes prior to the start of milking and continued till completion of milking; while the T3 group served as control representing the routine milking management system at C&B farm. The experiment was conducted for a period of 105 days.

Nutritional management

Green fodder (Berseem/Maize/Jowar) and concentrate feed was supplied to the animals as per the requirements in different seasons. The milking animals in all the groups were housed in loose housing system following standard management practices. Health and other management practices were carried out as per routine farm activities.

Milk yield and animal physiology

Machine milking method was used for milking of animals and daily individual milk yield was recorded in kilogram animal⁻¹. Individual cow milking time (min) was also recorded. Milking speed (kg min⁻¹) was calculated by using milk yield and milking time. Physiological variables such as rectal temperature and respiratory rate of animals were recorded at fortnightly intervals after milking. Rectal temperature was recorded by using a digital clinical thermometer. Respiration rate was counted from a distance by observing flank movements and expressed as counts per minute. Blood sampling was done at 90 days during the experimental period by puncturing the jugular vein following the aseptic measures. All the samples were analyzed in

Nuclear Research Laboratory (NRL), IVRI, Izatnagar for stress indicators like T₃, T₄ and cortisol hormone. For hormonal assay, the preserved serum was brought to the room temperature. Cortisol, T₃ and T₄ was estimated using standard Radio-Immuno Assay (RIA) kits (Erba Diagnostics Mannheim GmbH, Germany).

Behavioral activities of animals were also recorded during the experiment. Entry of animals in milking parlor, assembling in milking parlor, fear for milkers, feeding behavior, shaking of head and body parts, feed tossing, feeding time, kicking behavior during udder preparation, milk letting down behavior, abnormal behavior such as licking and knot tying were recorded.

Statistical analysis

The data obtained from the study was analyzed as per the method described by Snedecor and Cochran (1994). The mean was compared using SPSS (Version 20). The Kruskal–Wallis test was used for comparing behavioral parameters in different groups.

Results

Milk yield in *Vrindavani* crossbred cows

The initial milk yield in T1, T2, and T3 groups were 14.21±0.83, 13.88±0.98 and 14.75±0.55 respectively which exhibited a non-significant difference among the groups. Throughout the experiment there was a non-significant difference in milk yield among the groups. The overall mean milk yield in T1, T2 and T3 were 12.59±0.09, 12.85±0.07 and 12.57 ± 0.05 respectively.

Table 1. Mean fortnightly milk yield in *Vrindavani* crossbred cows (kg)

	Initial	I	II	III	IV	V	VI	VII	Overall
T1	14.21±0.83 ^a (7)	12.89±0.24 ^a (105)	12.72±0.21 ^a (112)	12.78±0.24 ^a (105)	12.67±0.28 ^a (105)	12.89±0.27 ^a (105)	12.47±0.21 ^a (112)	11.87±0.21 ^a (126)	12.59±0.09 ^a (770)
T2	13.88±0.98 ^a (7)	13.15±0.21 ^a (105)	12.89±0.18 ^a (112)	12.60±0.18 ^a (105)	12.65±0.18 ^a (105)	13.12±0.19 ^a (105)	13.07±0.22 ^a (112)	12.49±0.19 ^a (126)	12.85±0.07 ^a (770)
T3	14.75±0.55 ^a (7)	13.02±0.16 ^a (105)	12.95±0.15 ^a (112)	12.59±0.14 ^a (105)	12.45±0.14 ^a (105)	12.85±0.12 ^a (105)	12.51±0.14 ^a (112)	11.79±0.14 ^a (126)	12.57±0.05 ^a (770)

Means with different superscripts in column differ significantly at (P< 0.05)

Milking time in *Vrindavani* crossbred cows in different groups

There was a significant difference in milking time in the different groups. The milking time in animals during the initial stage was non-significant. The milking time in initial stage in T1, T2 and T3 groups was 11.96±0.44, 11.96±0.85 and 12.25±0.62 respectively. However, during the second fortnight T1 group showed a significant reduction in milking time as compared to T3 group, whereas it appeared aligned with that in T2 group. During the fifth fortnight T2 group showed a significantly lower milking time as compared to T3 group, whereas it was comparable to T1 group. The overall milking time was significantly lower in T1(10.67±0.06) and T2 (10.70± 0.05) over the control (10.98±0.06).

Table 2. Mean fortnightly milking time in *Vrindavani* crossbred cows in different groups (min)

	Initial	I	II	III	IV	V	VI	VII	Overall
T1	11.93±0.44 ^a (7)	9.39±0.20 ^a (105)	10.54±0.11 ^a (112)	10.89±0.14 ^a (105)	10.64±0.14 ^a (105)	11.37±0.12 ^{ab} (105)	10.97±0.11 ^a (112)	10.82±0.11 ^a (126)	10.67±0.06 ^a (770)
T2	11.96±0.85 ^a (7)	9.60±0.20 ^a (105)	10.57±0.11 ^{ab} (112)	11.05±0.12 ^a (105)	10.80±0.13 ^a (105)	11.04±0.11 ^a (105)	11.05±0.12 ^a (112)	10.77±0.09 ^a (126)	10.70±0.05 ^a (770)
T3	12.52±0.62 ^a (7)	9.96±0.21 ^a (105)	10.82±0.13 ^{ab} (112)	11.13±0.13 ^a (105)	10.95±0.12 ^a (105)	11.66±0.16 ^b (105)	11.16±0.14 ^a (112)	11.17±0.11 ^a (126)	10.98±0.06 ^b (770)

Means with different superscripts in column differ significantly at (P< 0.05)

Milk flow rate in *Vrindavani* crossbred cow

Milk flow rate differed significantly in the different groups. The milk flow rate among the cows during the initial stage was non-significant. However, during the fifth fortnight T2 group exhibited a significantly higher milk flow rate as compared to T1 and T3. During the sixth fortnight T2 group had significantly higher milk flow rate as compared to T3 group. Overall, both the musical treatments (T1 and T2) appeared efficiently enhancing the milk flow rate over the control.

Table 3. Mean fortnightly milk flow rate in *Vrindavani* crossbred cow (kg/min)

	Initial	I	II	III	IV	V	VI	VII	Overall
T1	1.18±0.04 ^a (7)	1.41±0.03 ^a (105)	1.21±0.02 ^a (112)	1.18±0.02 ^a (105)	1.19±0.02 ^a (105)	1.12±0.02 ^a (105)	1.13±0.02 ^{ab} (112)	1.09±0.02 ^a (126)	1.19±0.007 ^b (770)
T2	1.16±0.04 ^a (7)	1.39±0.02 ^a (105)	1.22±0.02 ^a (112)	1.14±0.02 ^a (105)	1.18±0.02 ^a (105)	1.18±0.01 ^b (105)	1.19±0.02 ^b (112)	1.16±0.02 ^b (126)	1.21±0.008 ^b (770)
T3	1.10±0.05 ^a (7)	1.34±0.03 ^a (105)	1.21±0.02 ^a (112)	1.14±0.02 ^a (105)	1.14±0.02 ^a (105)	1.11±0.01 ^a (105)	1.13±0.01 ^a (112)	1.06±0.01 ^a (126)	1.16±0.007 ^a (770)

Means with different superscripts in column differ significantly at (P< 0.05)

Respiration rate in *Vrindavani* crossbred cows

Rate of respiration among all the treatment groups remained almost similar with no significant difference. The overall respiration rate in T1, T2 and T4 groups was 22.73 ± 0.34, 22.2 ± 0.41 and 23.47 ± 0.35 respectively. Although the respiration rate was relatively higher in T3 group compared to music exposed groups, it remained statistically insignificant.

Table 4. Mean fortnightly respiration rate in *Vrindavani* crossbred cows (counts/min)

	I	II	III	IV	V	VI	Overall
T1	23.14±1.05 ^a	22.0±1.06 ^a	23.14±0.71 ^a	22.85±0.85 ^a	21.71±0.80 ^a	23.28±0.64 ^a	22.73±0.34 ^a
T2	22.28±0.52 ^a	21.71±1.47 ^a	22.85±1.14 ^a	22.28±0.68 ^a	21.14±1.14 ^a	22.28±0.68 ^a	22.2±0.41 ^a
T3	23.28±0.94 ^a	23.42±0.94 ^a	24.57±1.04 ^a	23.42±1.04 ^a	23.0±0.65 ^a	23.14±0.73 ^a	23.47±0.35 ^a

Means with different superscripts in column differ significantly at (P< 0.05)

Rectal temperature in *Vrindavani* crossbred cows

Rectal temperature also exhibited a similar trend as in case of respiration rate among all the treatments. The rectal temperature ranged from 100.08 ± 0.14, 99.82 ± 0.13 and 100.06 ± 0.15 in T1, T2 and T3 group respectively, indicating a non-significant interaction with the environmental enrichment through music.

Table 5. Mean fortnightly rectal temperature in *Vrindavani* crossbred cows (⁰ F)

	I	II	III	IV	V	VI	Overall
T1	99.9±0.34 ^a	99.84±0.41 ^a	100.35±0.39 ^a	100.2±0.7 ^a	100.45±0.23 ^a	99.74±0.43 ^a	100.08±0.14 ^a
T2	99.8±0.09 ^a	100.21±0.34 ^a	100.21±0.34 ^a	99.9±0.40 ^a	100±0.31 ^a	99.14±0.41 ^a	99.82±0.13 ^a
T3	99.95±0.26 ^a	100.24±0.35 ^a	100.24±0.35 ^a	100.78±0.31 ^a	100.62±0.37 ^a	99.17±0.40 ^a	100.06±0.15 ^a

Means with different superscripts in column differ significantly at (P< 0.05)

Hormone profile in *Vrindavani* crossbred cows

Profiling of T3 and T4 hormones revealed a statistically non-significant influence of musical enrichment of milking environment. However, cortisol hormone found to be significantly higher in T3 group over the T2 and T1 group. Thus, the results established an important positive interaction of musical enrichment on lowering the cortisol levels in dairy cows.

Table 6. Hormone profile in *Vrindavani* crossbred cows (nm/L)

	T ₃	T ₄	Cortisol
T1	2.56±0.20 ^a	43.64±3.21 ^a	61.85±10.37 ^{ab}
T2	2.47±0.15 ^a	42.05±4.60 ^a	49.11±10.89 ^a
T3	2.68±0.15 ^a	52.06±3.51 ^a	84.45±11.65 ^b

Means with different superscripts in column differ significantly at (P< 0.05)

Effect of music on milking behaviour in dairy animals

Measured behavioural characteristics such as entry of animals in milking shed, assembling in milking parlour, fear for milkers, feeding behaviour, feed tossing, feeding time, kicking behaviour, abnormal behaviour and behaviour during knot tying appeared almost similar in all the three groups. However, a significant effect of musical enrichment was evident on shaking of head and body parts which was more in T3 group (79.50) and reduced dramatically in T2 (50.81) and T1 group (60.58). Milk letting behaviour score was also higher in T2 (74.81) and T1 group (72.89), while least score was seen in T3 group (48.96).

Table 7. Effect of music on milking behaviour in dairy animals

Mean scores					
Attributes	T1	T2	T3	Chi square	P-Value
Entry of animals in milking shed	64.00 ^a	60.00 ^a	66.00 ^a	5.28	0.155
Assembling in milking parlour	71.50 ^a	69.50 ^a	55.50 ^a	7.85	0.049
Fear for milkers	67.50 ^a	66.0 ^a	63.50 ^a	7.63	0.054
Feeding behaviour	64.50 ^a	64.0 ^a	62.50 ^a	2.04	0.562
Shaking of head and body parts	60.58 ^b	50.81 ^b	79.50 ^a	14.93	0.002
Feed tossing	66.05 ^a	61.97 ^a	66.05 ^a	1.36	0.714
Feeding time	66.75 ^a	66.70 ^a	65.50 ^a	2.42	0.490
Kicking behaviour during udder preparation	63.44 ^a	61.31 ^a	71.72 ^a	5.72	0.126
Milk letting down behaviour	72.89 ^a	74.81 ^a	48.96 ^b	16.22	0.001
Abnormal behaviour such as licking	65.47 ^a	63.48 ^a	65.56 ^a	7.16	0.031
Behaviour during Knot tying	62.00 ^a	68.00 ^a	66.00 ^a	2.02	0.568

Means with different superscripts in rows differ significantly at (P< 0.05)

Discussion

Milk production in dairy animals is an interactive effect of both the genetic and environmental factors (Kunaka and Makuza 2005). Adverse environmental factors hinder the animal's real genetic ability of production (Missanjo et al. 2011). Environmental enrichment increases animals' physical activity, and also fulfills their psychological and behavior needs. Enrichment reduces stress, increases animal welfare, animal health and productivity. Different methods of environmental enrichment in animals include social, occupational, physical, sensory and nutritional. We used different Indian instrumental music to enrich the milking environment and investigate the influence on production performance, and behavior in cattle. The results reveal that, the effect of environmental enrichment through music of had a non-significant effect on milk yield. The milk yield is influenced by various factors, and the effect of music might be far lower as compared to the other factors that ultimately reflected a non-significant interaction. Therefore, the results indicate need of a precise experiment with a larger number of animals that could yield sound outcomes. The animals exposed to music required a significantly lower ($p < 0.05$) milking time as compared to the control group. Abuzead and Khalil (2007) reported that the latency (minutes) for buffalo cows from beginning of handling the teats till being psychologically and physically prepared to milking reduced significantly ($P < 0.01$) in the slow music group. Similar findings were also reported by Kıyıcı et al (2013) reported that music had no effect on milk yield, but it was found to have a positive impact on the milking time. Further, the milking speed was also significantly ($p < 0.05$) higher in animals exposed to music. The effect of environmental enrichment through music did not affect the respiration rate, rectal temperature, T3 and T4 hormones, however, the levels of cortisol were significantly lowered with the inclusion of music in milking environment (Table 6). The animals exposed to music also expressed higher milk let down behavioral score than control group. Similar findings were reported by (Lemcke et al 2021) that playing music in the barn or milking parlour might increase cow welfare by reducing stress and result in complete milking. Abuzead and Khalil (2007) found that milk cortisol of buffalo

cows in slow music group was significantly ($P < 0.05$) lower than that in fast music and control groups. A calming effect of music was evident on animals which might have helped in reducing the stress hormone that ultimately affected the milk let down and its effect on milking behavior. Similar findings were also reported by Roy et al., (2018), where lowering of stress was observed by a reduced cortisol level when music was played as compared to the cortisol level of the animals in control group. Fadlelmoula and Kaskous (2020) also reported a negative correlation between milk yield and concentration of cortisol in milking animals. Kıyıcı et al. (2013) used music as a measure to reduce stress levels in dairy cows during milking and found that Cows subjected to classical music for a period of 28 wk, compared with no music, had higher milk let-down speed (6.27 ± 0.12 min vs. 6.68 ± 0.13 min, respectively). Bobic et al., (2011) reported that onset of stress condition activates the sympathetic nervous system and hypothalamic-pituitary-adrenal axis, causing a hormonal change in the blood (increased levels of β endorphin, cortisol, ACTH, and catecholamines), that leads to disturbances in the release of milk, decreased productivity and decreased immunity. Further, removal of the music enrichment in animals has been linked to a significant increase in fecal cortisol and the heterophil:lymphocyte ratio, suggesting an increased level of stress (Peveler and Hickman 2018). Domestic animals react to stress by an alteration of behavioural and physiological responses (Deiss et al., 2009), which includes activation of the central nervous system, endocrine and immune systems that can ultimately influence the animal's production performance (Caroprese et al., 2010). This study also proved a marked ($p < 0.05$) effect of music on behavioural characteristics of milking cows such as shaking of head and body parts during milking. These results corroborate the findings of Wells and Irwin (2008) that reported a beneficial impact of auditory stimulation through classical music on reducing stereotypic behaviour in animals. Similarly, the use of auditory stimuli is also known to reduce abnormal behaviours such as tongue rolling which is an indicative of reduced stress and increased welfare and positive social interactions (Crouch et al 2019). The amplitude of music also influences the milk ejection, Algers and Jensen (1991) reported that dairy cows exposed to 80-100 dB of sound for 1.4-hour duration twice daily resulted in reduced milk yield in dairy cows and (Algers et al 1978) reported that it causes interrupted ejection. A stimulatory effect of music on calm behaviour, and readiness of cows to access the milking compartments is also reported in literature (Uetake et al 1995; Moregaonkar et al 2006) that further signify beneficial interactions of musical enrichment in dairy cows.

Conclusion

The results endorse beneficial effects of slow instrumental music in environments towards improving the behaviour and welfare of dairy animals. Further, a smooth movement of animals through the music barn could be useful to regulate the stress levels in animals and promote easy milk let-down. Musical enrichment is relatively easily accessible, user-friendly, economic technique with no environmental consequences. Thus, these findings have significant implications in the area of animal behaviour and welfare. Further precise studies with larger groups of animals are needed to reveal the underlying mechanisms of action of environmental enrichment through music in dairy animals.

Declarations

Author Contributions

Conceptualization: GKG, SAK; methodology: SAK, PKB; formal analysis: MK, HOP; supervision: GKV, VPM, SAK; statistical analysis: MRV; literature collection: NRS, SAK; writing and original draft preparation: SAK, PKB, NRS; writing, review, and editing: PKB, NRS, MS, GKV. All authors have read and approved the manuscript.

Acknowledgements

The authors are grateful for the support, encouragement and guidance received from the Director and all the Joint Directors, ICAR-IVRI, during the trial.

Conflict of interest

All the authors have carefully read and approved the manuscript and declare no competing interests.

Funding

The authors did not receive support from any organization for the submitted work.

Statement of animal ethics

Institutional guidelines of Indian Council of Agricultural Research-Indian Veterinary Research Institute (ICAR-IVRI) as per the Institute Research Council has followed experimenting.

Data Statement

The datasets generated during the current study are not publicly available as it will compromise the privacy of research but are available from the corresponding author on reasonable request.

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Figures

Figure 1

Mean fortnightly rectal temperature in Vrindavani crossbred cows (° F)