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Impact of community machine milking systems on microbiological quality of milk

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Abstract
An evaluation of two milking methods—hand milking system (HMS) and community machine milking system (CMS) in the jurisdiction of the Kolar-Chikkaballapura Milk Union Ltd. Karnataka, India was undertaken. 3 villages having functioning community milking stations were randomly selected from each district, giving a total of 6 villages. In each village, 12 dairy farmers, 6 using hand milking system and 6 using community milking system, were randomly selected. The milk microbiological quality of 216 lactating cows belonging to the respondents was studied. Somatic Cell Count (1.66±0.077) and Methylene Blue Reduction Time grade (1.97±0.058) were superior in HMS as compared to CMS (2.29±0.089 and 2.28±0.049, respectively), both being within the acceptable range, possibly due to lower level of sanitation in machine milking. There was no significance difference in CMS and HMS for California Mastitis Test. Better milk microbiological quality can be obtained in CMS by adoption of fore-stripping and mastitis testing; use of disposable paper napkins for wiping the teats; post-milking teat dipping and cluster sanitization; regular maintenance of milking machines; frequent inspection and replacement of liners, and adequate training of staff in maintenance of the milking machines.

Keywords: Community machine milking, hand milking, milk microbiological quality, somatic cell count, crossbred cows

Introduction
The livestock sector is an important subsector of agriculture in the Indian economy. India is ranked 1st in milk production, contributing 23 per cent of global milk production. Milk is the single largest agricultural commodity contributing 5 per cent of the national economy and employing more than 8 crore farmers directly. Milking operation is the major activity of every dairy farm affecting the quantity, quality and the cost of the milk produced. Milk quality is greatly affected by the method of milking, and in turn, has a direct bearing on the profitability of the farm. Good milking practices also enhance productivity, assist in keeping teat and udder in healthier condition and contribute significantly in clean milk production (Sabapara *et al.*, 2015) [16]. Hand milking is the common milking method in our country, with almost 90 per cent of dairy animals being milked by hand. The Kolar-Chikkaballapura District Co-operative Milk Producers' Union Ltd. (KOMUL) has started installing 'Community Milking Machines' on a pilot basis at the Society level from the year 2001 onwards to get the quality milk required for ultra-high temperature (UHT) milk processing at Kolar dairy under the brand name of 'Nandini Good Life' (Mohan Kumar *et al.,* 2015) [11].

Hygienic milking practices are one of the first and foremost steps in clean milk production. Clean milk production results in milk that is safe for human consumption, is free from disease-producing microorganisms, has a better keeping quality, thus yielding a product with high commercial value which is suitable for further processing. Milk needs to be protected from all possible sources of microbial contamination. Somatic Cell Count (SCC) is one of the important indicators of udder health and intramammary infections (Mansson *et al*., 2006) [12]. The right method and technique of milking is of the utmost importance as it has a direct bearing on the welfare and udder and teat health of dairy cows. Goodger *et al*. (1993) [7] reported that sanitation, milking equipment, cow condition, pre-milking procedures and mastitis control strategies have a significant role in reducing bulk milk somatic cell count.

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With the ever-increasing cost of agricultural labour, it has become imperative to mechanize various aspects of dairy farming; the most important being hand-milking operations which involve the most skill and drudgery. Small-scale alternatives to hand-milking, though popular, have associated drawbacks in the form of purchase cost of milking machine, time and money required for daily and periodic maintenance, irregular supply of spares, lack of timely repair in case of breakdown, investment in backup power systems, high operating costs etc. This study aims to compare the two milking systems – hand milking and community machine milking, in terms of their effect on the microbiological quality of the milk.

Materials and Methods
The study was carried out in the jurisdiction of the Kolar-Chikkaballapura Milk Union Ltd. (KOMUL), Karnataka during July-August 2022. Kolar District is situated at 13.1770°N Longitude, 78.2020°E Latitude, at an altitude of 849 metres (2,785 ft) above the mean sea level, and Chikkaballapura District is situated at 13.5229° N Longitude, 77.8367° E Latitude, at an altitude of 915 m (3,002 ft) above the mean sea level. Kolar and Chikkaballapura districts consist of 119 and 56 community milking machine parlours, respectively, comprising either 4, 6, 8 or 10 bucket units (DeLaval). In order to compare the efficiency of different milking systems, 3 villages having functioning community milking stations were randomly selected from each district, giving a total of 6 villages. In each village, 12 dairy farmers, 6 using hand milking system and 6 using community milking system, were randomly selected for the study. A total of 216 HF crossbred cows were evaluated. Parameters studied were California Mastitis Test (CMT) score, Somatic Cell Count (SCC) and Methylene Blue Reduction Test (MBRT).
The California Mastitis Test score was performed for the screening of the experimental samples against subclinical mastitis using California Mastitis Test kit (DeLaval). The CMT provides only an indication of somatic cell count, The CMT was performed on the milk samples as per procedure given by Schalm and Noorlander (1957) [18] employing a modified CMT reagent. About 3 ml of milk from a quarter was taken in a cup of the CMT paddle and an equal volume of reagent was added to it and the contents were mixed gently by horizontal rotation for 15-30 seconds and the results were recorded as per the Scandinavian CMT Test score.
Somatic Cell Count was estimated as per the general principle advocated by Prescott and Breed as detailed by Schalm *et al.* (1971) [17]. The SCC grade was classified (Hillerton, 1999 and Ambika *et al.*, 2021) [8, 1] as Very Good (<2,50,000 cells/ml, grade 1), Good (2,50,000-10,00,000 cells/ml, grade 2), Fair (10,00,000-50,00,000 cells/ml, grade 3) and Poor (>50,00,000 cells/ml, grade 4).
The MBRT test was performed as per BIS 1479 (Part 3, 1977) for determining the shelf-life of the milk samples of the two experimental groups. The grading was done based on the time taken for decolourization. The MBRT grade was classified as Very Good (≥5 hrs, grade 1), Good (3-4 hrs, grade 2), Fair (1-2 hrs, grade 3) and Poor (≤ 0.5 hrs, grade 4).

Results and Discussion
California Mastitis Test (CMT)
The data on California Mastitis Test (CMT) in 216 crossbred cows under different milking systems and districts is presented in Table 1. The CMT in hand milking and community machine milking systems was 1.06±0.027 and 1.19±0.042, respectively with overall mean of 1.13±0.025.

There is no significant ($p<0.05$) difference in the CMT in HMS and CMS. There was no significant ($p<0.05$) difference in the CMT in Chikkaballapura (1.14±0.036) and Kolar (1.11±0.036) districts. Further, there were no significant ($p<0.05$) differences between Chikkaballapura and Kolar districts with regard to the CMT in HMS and CMS. However, within each district, CMT was significantly ($p<0.01$) lower in HMS as compared to CMS in Chikkaballapura district, but there is no significant ($p<0.05$) difference in Kolar district.
The results are in agreement with Mamta *et al.* (2019) [10] who reported that no significant difference in machine milked cows (3.03%) samples and hand milked (4.55%) samples. Contrarily, Bhakat *et al.* (2016) [3] who reported the mean CMT score to be significantly ($p<0.01$) higher in hand milking (3.06±0.09) as compared to machine milking (1.35±0.06). Ritu (2019) [14] reported significantly ($p<0.05$) higher CMT scores in both pipeline (1.37±0.12) and herringbone machine milked (1.50±0.11) groups of cows, respectively as compared to hand milked cows (1.16±0.11). The California Mastitis Test (CMT) is a quick and easy method for detecting mastitis in cows

Somatic Cell Count (SCC)
The data on Somatic Cell Count (SCC) in crossbred cows under different milking systems and districts is presented in Table 2. The SCC in hand milking and community machine milking systems was 1.66±0.077 and 2.29±0.089, respectively with overall mean of 1.98±0.062. HMS had significantly ($p<0.01$) lower SCC than CMS. There was no significant ($p<0.05$) difference in the SCC in Chikkaballapura (2.00±0.077) and Kolar (1.95±0.098) districts. Further, there were no significant ($p<0.05$) differences between Chikkaballapura and Kolar districts with regard to the SCC in HMS and CMS. However, within each district, SCC was significantly lower in HMS as compared to CMS in both Chikkaballapura ($p<0.01$) and Kolar ($p<0.05$) districts.
The data on Somatic Cell Count Grade (SCC Grade) in 216 crossbred cows under different milking systems and districts is presented in Table 3. The SCC Grade in hand milking and community machine milking systems was 1.54±0.052 and 1.82±0.049, respectively with overall mean of 1.68±0.037. HMS had significantly ($p<0.01$) lower SCC Grade than CMS. There was no significant ($p<0.05$) difference in the SCC Grade in Chikkaballapura (1.68±0.049) and Kolar (1.69±0.055) districts. Further, there were no significant ($p<0.05$) differences between Chikkaballapura and Kolar districts with regard to the SCC Grade in HMS and CMS. However, within each district, SCC Grade was significantly ($p<0.01$) lower in HMS as compared to CMS in Chikkaballapura district, further there is no significant ($p<0.05$) difference in HMS and CMS in Kolar district.
The results are in agreement with Singh *et al.* (2014) [19] who reported that milk SCC was more ($p<0.05$) in machine milked group (1.20±0.07) than in hand milked group (0.97±0.23) in Murrah buffalo. Ritu (2019) [14] reported that the overall mean SCC (×103 cells/ml) was significantly ($p<0.05$) higher in herringbone and pipeline machine milked groups of cows (147.65±10.04) and (185.79±11.94) as compared to the hand milked group of cows (102.48±12.09). However, De *et al.* (2011) [6] observed higher, though statistically non-significant, SCC in buffaloes milked with machine (1.12±0.11 × 105 cells/ml) as compared to hand milked Murrah buffaloes (0.94±0.05 × 105 cells/ml). In contrast, Barot *et al.* (2021) [2] reported the mean value of SCC to be higher in hand milked (1.72±0.11 lakhs cells/ml) as compared to machine milked (1.55±0.05 lakhs cells/ml) cows, difference being non-

significant. Dang and Anand (2007) [5] reported significantly ($p<0.01$) higher SCC in hand milked animals (2.27 x 105 cells/ml) as compared to machine milked cows (1.66 x 105 cells/ml). Omer *et al.* (2005) [13] reported significantly ($p<0.05$) higher SCC (x 103 cells/ml) in hand milking (655.167±88.133) as compared to machine milking (389.167±60.131).

The higher levels of somatic cell count in machine milking may be attributed to vacuum fluctuations or may be due to low levels of sanitation of the milking machine systems (Ritu, 2019) [14]. In addition, it was observed that the milking machine claws were not cleaned after each milking, regular monitoring and replacement of teat cups liners was not practiced, there was a delay in servicing of the milking equipment, and the operators of milking machines were not fully trained in maintaining and servicing of equipment.

Methylene Blue Reduction Test Grade (MBRT)

The data on Methylene Blue Reduction Test Grade (MBRT Grade) in 216 crossbred cows under different milking systems and districts is presented in Table 4. The MBRT Grade in hand milking and community machine milking systems was 1.97±0.058 and 2.28±0.049, respectively with overall mean of 2.13±0.039. CMS had significantly ($p<0.01$) higher MBRT Grade than HMS. There was no significant ($p<0.05$) difference in the overall MBRT Grade in Chikkaballapura (2.03±0.055) and Kolar (2.22±0.055) districts. While there was no significant ($p<0.05$) difference with regard to MBRT Grade in HMS among the districts, Kolar district had significantly ($p<0.01$) higher MBRT Grade under CMS. Further, there is significant ($p<0.05$) higher MBRT Grade in CMS than HMS in Chikkaballapura district, CMS had significantly ($p<0.01$) higher MBRT Grade in Kolar district.

The results are in agreement with Lakhani and Jogi (1996) [9] who reported that the average MBRT for milk obtained by machine milking was significantly ($p<0.01$) higher than hand milking; they concluded that average keeping quality of milk under hand and machine milking were 8.5 and 10.5 hours, respectively. In contrast, Rohit and Kamboj (2010) [15] found that MBRT was significantly higher ($p<0.01$) in milk from hand-milked buffaloes than in machine-milked buffaloes. The higher MBRT grade in machine milking may be due to the fact that the teats are mechanically stimulated and the milk is collected through a series of tubes. This process can potentially introduce bacteria into the milk if the equipment is not properly sanitized or if there is any contamination present on the cow's teats or in the environment.

Table 1: Comparison of California Mastitis Test in crossbred cows under hand milking and community machine milking systems in different districts of Karnataka.

Milking System	District		Overall	P-value
	Chikkaballapura	Kolar		
Hand	1.06±0.031[a]	1.07±0.045[a]	1.06±0.027	0.735
Community machine	1.22±0.063[b]	1.15±0.055[a]	1.19±0.042	0.379
Overall	1.14±0.036	1.11±0.036	1.13±0.025	0.700
P-value	0.020	0.301	0.092	

Note: Means within a column having different superscripts differ significantly ($p<0.05$).
There were no significant differences among any of the row-wise means.

Table 2: Comparison of Somatic Cell Count (x10^{5} cells/ml) in crossbred cows under hand milking and community machine milking systems in different districts of Karnataka.

Milking System	District		Overall	P-value
	Chikkaballapura	Kolar		
Hand	1.59±0.055[a]	1.74±0.145[a]	1.66±0.077[a]	0.359
Community machine	2.41±0.122[b]	2.17±0.128[b]	2.29±0.089[b]	0.177
Overall	2.00±0.077	1.95±0.098	1.98±0.062	0.783
P-value	0.000	0.027	0.000	

Note: Means within a column having different superscripts differ significantly ($p<0.05$).
There were no significant differences among any of the row-wise means.

Table 3: Comparison of Somatic Cell Count Grade in crossbred cows under hand milking and community machine milking systems in different districts of Karnataka.

Milking System	District		Overall	P-value
	Chikkaballapura	Kolar		
Hand	1.48±0.069[a]	1.59±0.077[a]	1.54±0.052[a]	0.284
Community machine	1.87±0.059[b]	1.78±0.078[a]	1.82±0.049[b]	0.346
Overall	1.68±0.049	1.69±0.055	1.68±0.037	0.930
P-value	0.000	0.094	0.005	

Note: Means within a column having different superscripts differ significantly ($p<0.05$).
There were no significant differences among any of the row-wise means.

Table 4: Comparison of Methylene Blue Reduction Test Grade in crossbred cows under hand milking and community machine milking systems in different districts of Karnataka.

Milking System	District		Overall	P-value
	Chikkaballapura	Kolar		
Hand	1.91±0.089[aX]	2.04±0.075[aX]	1.97±0.058[a]	0.266
Community machine	2.15±0.061[bX]	2.41±0.072[bY]	2.28±0.049[b]	0.007
Overall	2.03±0.055	2.22±0.055	2.13±0.039	0.080
P-value	0.028	0.001	0.005	

Note: Means within a column ([ab]) or row ([XY]) having different superscripts differ significantly ($p<0.05$)

Conclusion

Based on the findings of the present study, it can be concluded that the method of milking has a significant impact on milk quality. While there was no significant difference in California Mastitis Test in both milking systems, Somatic Cell Count and Methylene Blue Reduction Test were better in HMS as compared to CMS, both being within the acceptable range, possibly due to lower level of sanitation in machine milking. These can be improved by adoption of fore-stripping and mastitis testing; use of disposable paper napkins for wiping the teats; post-milking teat dipping and cluster sanitization; regular maintenance of milking machines; frequent inspection and replacement of liners, and adequate training of staff in maintenance of the milking machines.

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