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Factors affecting raw milk quality in dairy value chain in Rajasthan (India): A comprehensive study

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ABSTRACT

This paper outlines the quality of raw milk in the dairy value chain of Rajasthan and brings out the various factors and their association with raw milk quality. Four milk unions viz. Alwar, Bhilwara, Bikaner and Hanumangarh of Rajasthan Cooperative Dairy Federation (RCDF) were selected purposively. A list of dairy farmers of each DCS (Dairy Co-operative Society) was prepared, and 120 farmers were selected on the basis of proportionate random sampling. To analyze the factor affecting raw milk quality, milk samples were collected from three levels viz. pail, DCS and dock. The raw milk quality in the milk shed area of RCDF was affected by socio-economic factors, viz. social participation, education, experience in dairying and milk sale. Path analysis revealed various factors having substantial direct effect on milk quality at pail, DCS and at dock level.The impact of clean milk production (CMP) programme on the milk quality was positive at all the levels of dairy value chain.

Key words: CMP, DCS, Dock, Knowledge, Milk quality, Pail

India is the leading milk producer in the world by producing 132.4 million tone milk (2012–13) with the growth rate of 4.39% (2003–2013), which provides an assurance for per capita milk availability of 290 g (DADF 2013). India has low farm gate prices and proximity to milk deficit market of neighboring countries, which can be leveraged to enhance exports. However, India has not been able to compete in global markets mainly due to low quality and hygiene standards (FICCI 2010). Indian dairy sector needs to build its competitiveness on the basis of quality, productivity and efficiency to continue its match towards success in national and international market (Kurien 2004). Quality of raw milk, conditions of transportation of milk and the lack of skilled manpower are the major factors that impact the quality of the processed milk products vis-a-vis the prescribed standards.

Clean milk production (CMP) programme: The quality of raw milk in India is relatively poor and the initial bacterial counts are high. The production of high quality milk is vital for dairy producers to remain competitive in the global dairy industry (Ruegg and Pantoja 2013). It is therefore very essential to promote CMP. In this direction, two new schemes were started by the Department of Animal Husbandry, Dairying and Fisheries (DADF), viz. CMP programme in 2003 through State Cooperative Dairy Federations for strengthening the infrastructure for quality and CMP; and Dairy Capital Venture Fund, implemented in 2005–06 through National Bank for Agriculture and Rural Development (NABARD) to provide financial assistance for small dairy farms; milking machines, dairy processing equipment; establishment of the cold chain facilities for milk and milk products; private veterinary clinics etc (DADF 2013).

The primary objective of CMP programme was to create necessary physical infrastructure in the form of stainless-steel buckets, milking pails, disinfectants etc, for the production of good quality raw milk and milk products, right from the stage of milking down to the point of consumption.

MATERIALS AND METHODS

The study was conducted in the state of Rajasthan, with an objective to assess the quality of raw milk at various levels of the dairy value chain and the factors affecting raw milk quality at various levels in the milk shed area of Rajasthan Cooperative Dairy Federation (RCDF). The study provides an insight into various factors influencing the practicing of CMP which in turn helps in improving raw milk quality in dairy value chain.

RCDF is the organized dairy value chain, which was established in 1975. At present, RCDF is having 21 district cooperative milk unions. Out of 21 Unions, four district milk Unions were selected for the present study by using multistage proportionate random sampling procedure. The study was organized in 2006–07 and revalidated in 2012–13, mainly focused on raw milk quality and its factors. So it was utmost important to select only those milk unions which are having sufficient number of Dairy Cooperative

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Societies (DCSs), under CMP programme. In view of all these parameters, four milk unions, namely; Alwar, Bhilwara, Bikaner and Hanumangarh of RCDF were selected purposively. Out of them, Bikaner and Hanumangarh milk unions represent desert area and all these were registered under HACCP standards and ISO–2000. All milk routes in each milk union were divided into two categories, namely; CMP route and Non-CMP route. Such type of distribution of sample size was done in assessing the comparability between CMP and Non-CMP route. A list of dairy farmers of each DCS, who were pouring milk for the last two years, was prepared, and a total of 120 farmers was selected on the basis of proportionate random sampling.

The information on different aspects of the respondents was collected with the help of the structured interview schedule. The milk samples were collected at three different levels of dairy value chain viz. milk producer (pail), DCS, and milk union (dock). Methylene Blue Reduction Test (MBRT) of quality measurement was used to assess the quality of the samples. Results of milk quality samples were categorized on the basis of Codex and ISO standards of MBRT test. The path analysis was used to know the direct and indirect relationship between socio-economic factors of the raw milk quality at different level of dairy value chain.

RESULTS AND DISCUSSION

Socio-economic characteristics: A cursory view of the socio-economic characteristics of dairy farmers revealed that majority of them were middle aged, ranging between 34 and 51 years. This is working age group, where an individual gives his full of strength to livelihood and adopt new initiatives for the betterment, job security and profit. In terms of education, most of them are illiterates (26.70%) followed by those with metric level of education. In such situation, training programmes are essential to equip the knowledge level of dairy farmers to produce good quality raw milk. To fill-up this gap, CMP programme already introduced in the study area, which is now an essential activity of all milk unions of RCDF. Interestingly, family education status was of medium level; which may be due to the fact that experience in dairy farming provides stability in dairy business.Regarding the family size, 70.84% respondents had medium (i.e. 6 to 9 members) family size, which indicates that dairying is the major source of income for the family and provides livelihood in the desert state. Majority of them had medium level of social participation (68.34%) where interaction with outside agencies provides a chance to meet varied information needs for dairying. Land holding provides support to dairy farming by its by-products, viz. fodder, concentrates, green grasses etc. and it gives sustainability to the milk production.

In the present study, 40.84% of the dairy farmers had 2 to 4 ha, followed by 27.50% who belong to small land holding. Three-fourths of the respondents were having medium herd size, with 3 to 9 animals. It is evident that dairy farming is important occupation in the area and farmers were supportive to CMP practices. Income is an attractive aspect of any enterprise, especially in dairying, where producer get his instant payments for milk sale. The result revealed that majority of dairy farmers were having their annual income between ₹ 100,001 to 150,000/annum, which is now doubled with incentives and other motivating factors. These findings are in contrast to the observations of various researchers, viz. Dechow (2011), Raval and Chandawat (2011), Gebrekidan *et al.* (2012), Singh and Datta (2013) and Mali *et al*. (2014).

Raw milk quality: Majority of the dairy farmers were using stainless steel (SS) utensils at pail and DCS level. The difference of time for milk procurement between pails to DCS level was 97 min (1.37 h), while it was 261 min (4.21 h) for pail to dock level. On the basis of milk quality, Dhanpura DCS of Bhilwara Union was on first rank for pail and DCS; and second for the dock level, with 6.55, 5.27 and 1.54 h MBRT, respectively. On the other hand, Bagthala and Mundawar DCSs of Alwar union were on least score at the pail and DCS level, with 5.18 and 3 h MBRT, respectively. The Barsingsar DCS of Bikaner milk union was on the last rank with 19 min MBRT at dock level. The overall milk quality results showed that Bhilwara milk union was on first rank for quality milk production, followed by Alwar, Hanumangarh and Bikaner.

The study revealed that the status of CMP in the form of milk quality in Rajasthan state was very good at pail, good at DCS and fair at dock level of milk collection, as per ISO standards, respectively (Singh and Gupta 2014). There are some other findings from India and abroad which has yielded similar results like Aaglave and Wadatkar (2012), Prabhavathy and Sowmya (2012), Jain and Shrivastava (2014), Khan *et al*. (2014), and Surkar *et al.* (2014).

The study revealed that the impact of CMP practices proved the improved quality of raw milk at pail and DCS level, but at dock level quality was affected due to distance, temperature and time difference. RCDF emphasize the importance of this programme and with the help of DADF 608 Bulk Milk Coolers (BMCs) have been installed in different milk unions. Bhilwara union was one of the Union of the RCDF which had all DCS connected with 158 BMCs followed by Alwar, Ganganarg and Hanumangarh and Bikaner. Moreover, to reduce the time in collection, weighing and milk testing, most of the DCSs were equipped with Electronic Milk Tester (EMT), Automatic Milk Collection Unit (AMCU), Automatic Milk Collection Station and milk analyzers. The average MBRT of milk in BMC route was 3.0 h and standard plate count is 5.0 lakh at dock level, but in general routes it was 90 minutes and 25 lakh respectively.

Effect of socio-economic factors on the milk quality at different milk collection levels: The path analysis was carried out to know the direct and indirect effect of socio-economic factors of dairy farmers on the milk quality at different levels, viz. pail, DCS and dock of dairy value chain.

Effect of socio-economic factors on the milk quality at pail level: Path analysis (Table 1) clearly indicated that

direct effect on milk quality was only in the variables such as social participation (0.338), annual income (0.227), experience in dairying (0.137) and family size (0.117). On the other hand, the total indirect effect was found higher in variables like herd size, milk sale, annual income, family education status, and milk production. It indicated that these variables not only influence the milk quality at pail level directly, but also indirectly through other accompanying exogenous variables. It was also noted that substantial indirect effects of exogenous variables have been channeled through social participation and annual income, experience in dairying, milk production, education and family education status and family size and milk sale. Therefore, it can be inferred that the variables viz. experience in dairying, family size, social participation and annual income were not showing a direct effect on clean milk whereas they were responsible for changing the effects for accompanying variables. In conclusion, it appeared that all these variables together played a dominant role in influencing the milk quality at pail level.

Effect of socio-economic factors on the milk quality at DCS level: Path analysis clearly indicated that large direct effect on milk quality was found in the variables such as social participation (0.486), land holding (0.252), age (0.231), experience in dairying (0.229), milk sale (0.202), annual income (0.118) and milk consumption (0.167).

On the other hand, the total indirect effect was found highest in variables like herd size, annual income, family education status, milk sale, and milk consumption etc. It indicated that these variables not only influence the milk quality at DCS level directly, but also indirectly through other accompanying exogenous variables. It was also noted that substantial indirect effects of exogenous variables have been channeled through social participation, milk sale, experience in dairying and land holding, age, education, milk production and consumption and annual income. Therefore, it can be inferred that age, experience in dairying, social participation, annual income and milk production, consumption and sale had not only direct affect, but also they were responsible for changing the effects for accompanying variables. It can be concluded that all these variables played a dominant role in influencing the milk quality at DCS level.

Effect of socio-economic factors on the milk quality at dock level: Direct effect (Table 3) on milk quality was found through the variables such as milk consumption (0.421),

Table 1. Effect of socio-economic factors of dairy farmers on milk quality at Pail level

Variables	Direct effect	indirect effect	Substantial indirect effect channeled through		
			1	2	3
Age (X_1)	-0.011	0.138	0.109 (X_4)	0.051 (X_2)	0.061 (X_6)
Education (X_2)	0.095	0.044	0.059 (X_4)	0.045 (X_6)	0.034 (X_3)
Family education status (X_3)	0.084	0.286	0.170 (X_6)	0.056 (X_9)	0.038 (X_2)
Experience in dairying (X_4)	0.137	0.163	0.122 (X_6)	0.079 (X_9)	0.041 (X_2)
Family size (X_5)	-0.117	0.161	0.067 (X_9)	0.042 (X_6)	0.034 (X_4)
Social participation (X_6)	-0.338	0.251	0.110 (X_9)	0.049 (X_4)	0.042 (X_3)
Land holding (X_7)	-0.030	0.243	0.092 (X_6)	0.083 (X_9)	0.053 (X_4)
Herd size (X_8)	0.031	0.320	0.155 (X_9)	0.053 (X_4)	0.046 (X_{10})
Annual income (X_9)	0.227	0.296	0.164 (X_6)	0.055 (X_{10})	0.052 (X_{12})
Milk production (X_{10})	0.097	0.239	0.130 (X_9)	0.090 (X_6)	0.054 (X_{12})
Milk consumption (X_{11})	-0.057	0.183	0.075 (X_9)	0.073 (X_{10})	0.059 (X_5)
Milk sale (X_{12})	0.073	0.416	0.162 (X_9)	0.156 (X_6)	0.072 (X_{10})

Table 2. Effect of socio-economic factors of dairy farmers on milk quality at DCS level

Variables	Direct effect	indirect effect	Substantial indirect effect channeled through		
			1	2	3
Age (X_1)	-0.231	1.272	0.183 (X_4)	0.051 (X_7)	0.048 (X_2)
Education (X_2)	-0.089	0.158	0.125 (X_1)	0.099 (X_4)	0.065 (X_6)
Family education status(X_3)	0.082	0.334	0.246 (X_6)	0.057 (X_{12})	0.036 (X_2)
Experience in dairying(X_4)	0.229	0.024	0.184 (X_1)	0.175 (X_6)	0.098 (X_7)
Family size (X_5)	0.036	0.064	0.085 (X_{11})	0.062 (X_1)	0.060 (X_6)
Social participation (X_6)	0.486	0.157	0.094 (X_{12})	0.082 (X_4)	0.069 (X_7)
Land holding (X_7)	-0.252	0.218	0.132 (X_6)	0.089 (X_4)	0.081 (X_1)
Herd size (X_8)	-0.058	0.354	0.130 (X_6)	0.127 (X_{12})	0.089 (X_4)
Annual income (X_9)	0.118	0.329	0.237 (X_6)	0.144 (X_{12})	0.092 (X_7)
Milk production (X_{10})	0.127	0.156	0.149 (X_{12})	0.130 (X_6)	0.125(X_{11})
Milk consumption (X_{11})	-0.167	0.215	0.095 (X_{10})	0.074(X_{12})	0.062 (X_7)
Milk sale (X_{12})	0.202	0.321	0.226(X_6)	0.093 (X_{10})	0.084 (X_9)

Table 3. Effect of socio-economic factors of dairy farmers on milk quality at dock level

Variables	Direct effect	indirect effect	Substantial indirect effect channeled through		
			1	2	3
Age (X_1)	0.073	0.089	0.119 (X_4)	0.116 (X_7)	0.088 (X_{11})
Education (X_2)	-0.066	0.055	0.064 (X_4)	0.040 (X_1)	0.038 (X_{11})
Family education status(X_3)	-0.054	0.176	0.112 (X_6)	0.071 (X_{12})	0.059 (X_4)
Experience in dairying (X_4)	-0.149	0.136	0.129 (X_7)	0.101 (X_{11})	0.086 (X_{12})
Family size (X_5)	0.336	0.149	0.214 (X_{11})	0.055 (X_{12})	0.047 (X_{10})
Social participation (X_6)	0.222	-0.007	0.115 (X_{12})	0.090 (X_7)	0.053 (X_4)
Land holding (X_7)	-0.332	0.065	0.104 (X_{11})	0.060 (X_6)	0.058 (X_4)
Herd size (X_8)	-0.038	0.157	0.156 (X_{12})	0.150 (X_{11})	0.109 (X_5)
Annual income (X_9)	0.036	0.129	0.177 (X_{12})	0.122 (X_7)	0.108 (X_6)
Milk production (X_{10})	0.148	-0.079	0.317 (X_{11})	0.183 (X_{12})	0.108 (X_5)
Milk consumption(X_{11})	-0.421	0.295	0.171 (X_5)	0.111 (X_{10})	0.091 (X_{12})
Milk sale (X_{12})	0.248	0.004	0.155 (X_{11})	0.109 (X_{10})	0.103 (X_6)

family size (0.336), land holding (0.332), milk sale (0.248), social participation (0.222), experience in dairying (0.149) and milk production (0.148). On the other hand, the total indirect effect was found higher in variables like milk consumption, herd size, annual income, family education status etc. It indicated that these variables not only influence the milk quality at dock level directly, but also indirectly through other accompanying exogenous variables.

It was also noted that substantial indirect effects of exogenous variables were channeled through milk sale, milk consumption, and experience in dairying, social participation, land holding, family size, milk production and age. Therefore, it can be inferred that milk consumption, land holding, family size, social participation, milk production and milk sale were not only showing direct effect, but were also indirectly influencing milk quality through accompanying variables. Thus, it can be concluded that all these variables played a dominant role in influencing the milk quality at dock level.

Our results indicated that there was difference between variables of milk collection causing direct and indirect effects on milk quality. This might be due to the different package of practices for each level of milk collection. At pail level, a farmer himself cleans the dairy animals with traditional practice, but at DCS level cleaning of utensils is supervised by secretary, which depends on his education and experience about CMP practices. At dock level, there is no role of farmer and that is why, Table 3 is showing less direct and indirect effect of variables on milk quality. In short, we can say CMP is not exclusively in the hands of farmers but dairy plant managers and other staff of dairy plants have an important role in maintaining milk quality.

The overall relationships between socio-economic factors of dairy farmers and milk quality indicate that the factors, viz. family education status, experience in dairying, social participation, annual income, milk production and milk sale were actively playing their role in enhancing and decreasing milk quality at different levels of milk collection.

However, précised results of relationship showed that the variable, viz. social participation played a key role at all the levels of milk collection to a great extent, for which the reason could be that, the present study was conducted under cooperative societies of RCDF, where group meetings, group discussions, training programmes, educational tours, field days and result and method demonstrations were routine activities. Other than these activities, annual election for chairmen, members, secretary and general body meetings of milk unions were the main pathways for enhancing the social participation.

Knowledge level of the dairy farmers regarding CMP practices: The study indicated that 55.84% of the dairy farmers had medium level of knowledge in various aspects of CMP, followed by 33% and 20% having low and high level of knowledge, respectively. They had higher knowledge in 'Housing', followed by 'Milking'. However, they had poor knowledge in 'Cleaning of animal' and 'Cooling of milk'. These results indicate that dairying is the enterprise which provides livelihood in the study area, where traditional knowledge helps in housing and milking aspects. But, due to lack of water availability and high environmental temperature, they were found scoring low in cleaning of animal and cooling aspects. It is also important that all the unions of RCDF are having separate training units, which organize different field orientation programmes on CMP practices and equip the farmers with new knowledge (Singh and Gupta 2015).

Adoption level of the dairy farmers regarding CMP: It was observed that 71.67% of the dairy farmers had medium level of adoption in various aspects of CMP, followed by 13.33% and 15.00% having low and high level of adoption, respectively. It was also found that they adopted recommended practices of 'Transportation' up to maximum extent, followed by 'Feeding'. However, extent of adoption regarding 'Cleaning of utensil' and 'Healthy herd management' was less.

All the 4 milk unions had their well-established transport system of milk routes, where milk vans are collecting milk from DCS and supplying it to the dock. This system was upgraded with the support of CMP programme, where bulk milk coolers (BMCs) are installed at DCS to reduce the bacteriological load of raw milk. The DCS members (dairy farmers) are trained on meeting the desired time schedule

for supply of milk from pail to DCS. All the unions are having a proper supply of animal feed from RCDF's feed plants. Each DCS is getting desired amount of animal feed (concentrates) for getting good milk yield. As already mentioned, lack of water availability and improper knowledge about veterinary and housing aspects affect the cleaning of utensils and healthy heard management (Singh and Gupta 2015).

Communication behaviour of dairy farmers regarding CMP: In this part, an attempt was made to study the 2 aspects of communication behaviour, viz. information seeking behaviour and information dissemination behaviour of dairy farmers. Most of the dairy farmers used friends, progressive milk producer, veterinary officer and neighbours as information sources; group discussion, group meetings, newspaper and DCS were important channels for information seeking about proper 'cattle shed' and 'milking procedure'. However, milk route supervisor, progressive milk producer, friends and neighbours were found as major information sources; whereas, DCS, educational tour and group discussion were important channels for information used by the dairy farmers for information seeking about 'cleaning of utensil' and 'post milking practices'. These results are in conformity with the findings of Khan *et al.* (2010), Punitha *et al.* (2013), Rastogi and Hasan (2014), and Singh *et al*. (2014) in this field.

Comparison between CMP and non-CMP milk routes regarding different variables: Being a comprehensive study, which included all the relevant aspects of CMP, the components which influenced the status of CMP, such as knowledge, adoption, milk quality, communication behaviour etc. were measured. At the time of planning, it was decided that to measure the status of CMP, both type of milk routes (CMP and Non-CMP) should be in the selection which will be able to give a clear picture of CMP status. All the above discussed results showed the overall scenario of CMP in both types of milk routes. To obtain a clear picture, data were arranged in the Table 4, which apprehend the comparison of CMP and of Non-CMP milk routes with reference to all the variables in the study.

The results showed the significant impact of CMP programme on the milk quality. Moreover, the difference in knowledge level was somewhat low i.e. 11.66, which explained that, the dairy farmers already had some knowledge regarding milk quality management, but they did not use it consciously. After the inception of CMP programme, the awareness increased considerably, which indicated significant difference in adoption with score of 13.72. Further results indicated that, there was a remarkable difference between programme and non-programme area regarding communication behaviour, with a score of 74.15. It might be due to different extension activities, used by all milk unions, viz. educational tour for CMP, farmers training at union and research stations, dissemination of relevant literature, follow-up of training prorgrammes, distribution of awards and rewards etc.

Table 4. Comparison between CMP and Non-CMP milk routes regarding different variables

Variables	CMP milk routes	N-CMP milk routes	Difference
	(criteria of score was mean value)		
MBRT at Pail level	385.81	331.16	54.65
MBRT at DCS level	294.50	207.16	87.34
MBRT at Dock level	61.11	41.86	19.25
Knowledge level	37.46	25.80	11.66
Adoption level	76.95	63.23	13.72
Communication behaviour	191.24	117.09	74.15

Raw milk quality is the base for milk products' shelf life, which can be improved by using CMP practices. CMP progamme is the major initiative, which starts from animal udder and extends up to processing plant. The present study concludes that family education status, experience in dairying, social participation and milk sale had direct and indirect effect on milk quality at different levels of dairy value chain. The overall conclusion of raw milk quality in dairy value chain of RCDF was found 'very good' at pail, 'good' at DCS and 'fair' at dock level. These results are the outcome of CMP programme which gave the proven status of raw milk quality at RCDF. So far under this scheme, 7.03 lakh farmers have been trained and 2,231 bulk milk coolers with a total chilling capacity of 4,613,800 liter/day were installed and 1,542 existing laboratories were strengthened at national level.

On the basis of results and field experience of the researchers, this study recommends that to improve the udder health and maintaining the hygiene at producer level, continuous follow-up CMP trainings and use of stainless steel utensils should be made compulsory. Milk payment at DCS should be based on the raw milk quality, which motivates the dairy farmers for maintaining raw milk quality by using CMP practices. Research institutes should develop low cost bacterial quality testing kits or methods, in affordable prices. All DCSs should be equipped with BMC and distance of milk routes and travel time should be reduced.

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