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Factors Affecting the Quality of Raw Milk: Effect of Time Taken for Transportation and Practices at Field Level in Small Farms in Sri Lanka

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Research Article

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ABSTRACT

The bacterial load prior to the pasteurization affects the efficiency of pasteurization. This research was carried at the Milco dairy factory, milk chilling centers and farmers' fields in Sri Lanka to investigate possible causes for microbial load of raw milk received by the factory. Milk samples obtained aseptically from bowsers reaching the factory were used for microbiological analysis and evaluation of quality by using platform tests. Time taken for transportation of chilled milk contributed most on the bacterial density of raw milk. Improper field level practices were also identified as the other major contributing factor. The quality of raw milk is high in Ampitiya, Anamaduwa, Dodangaslanda, Galgamuwa, Norwood, Kotagala and Maho where better sanitary conditions were observed at field level. Poor sanitary conditions in dairy farming in Galle, Gonapinuwala, Horana, Nittambuwa, Moonamaldeniya, Polgahawela and Thihagoda resulted in high initial bacterial density. It is concluded that, time taken for transportation of chilled milk is a major factor affecting microbial load at the reception of milk at the processing factory, while good field level practices should be maintained to improve the quality of milk. Milk from small scale cattle farms in dry zone and cooler areas in upcountry yielded better quality milk than those from wet zone. Recommendations to improve the quality of milk by encouraging the farmers to observe good hygienic practices are suggested.

INTRODUCTION

Milk is defined to be the lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows, five days after and fifteen days before parturition [1].

Quality of the raw milk depends on its microbial density and various factors effect on the number and types of microorganisms in raw milk [2]. Causes of higher bacterial counts include poor pre-milking hygiene methods, inadequate cleaning and sanitization of milk equipment, poor cooling and in some cases, mastitis. Good production and herd management practices help ensuring low bacteria counts and reduce the risk of pathogen contaminations raw milk [3].

Although pasteurization process can destroy most of bacteria in raw milk, shelf life of pasteurized fluid milk is influenced by the quality of raw milk [4]. As such maintaining high quality raw milk at farm level is very important, and hence, the first steps in preserving the quality of milk must be taken at the farm.

In Sri Lanka, several large scale milk processing installations are operating, and small scale industries and processing at cottage level are scattered all over the country. According to the farm registration program 2008/2009 of Department of Animal Production and Health (DPAH), there are about 7400 farms operate with over twenty dairy cows. Several farms such as Ambewela, New Zealand, Bopaththalawa, Dayagama, Ridiyagama, Manikpalama have over hundred of dairy cows [5]. All other milk processing depends on small scale farms. Milco (Pvt.) Ltd., where this research was carried out entirely rely on small scale farmers. Milk is collected from collecting centers, chilled and transported to the factories. Narahenpita (in Colombo) Factory is the largest

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installation of the company and receives milk from one hundred and eight collecting centers.

The effect of time spent in transporting milk in bowsers was studied as a possible contributing factor for quality of milk received at the factory. Investigating the relationship between the qualities of milk with practices at the farmer level was the other purpose in the present study.

MATERIALS AND METHODS

Sample Collection

Over the period of April 2012 - April 2014 raw milk was sampled from bowsers which reached to factory from 25 chilling centers. In addition to that, farmers were interviewed using questionnaire to collect information about the sanitary and other practices at the field level. **Figure 1** shows the locations of chilling centers sampled. **Figure 1** also indicates the climatic zones in which these sampling sites are located.

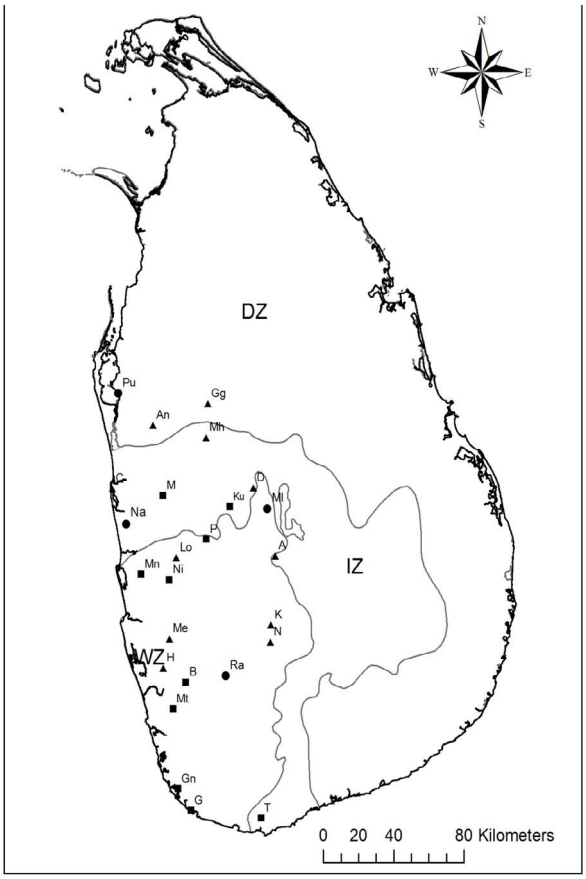

Figure 1. Map of Sri Lanka showing the locations of milk chilling centers sampled and the climatic zones of these locations. Symbols indicate chilling centres above (■), below (▲) and on or close to (●) trend line in **Figure 2**.

Effect of Time Taken for Transportation on Bacterial Counts of Raw Milk

Standard Colony Count (SCC) method was followed for milk, sampled from milk bowsers which reached the factory from different milk chilling centers and was serially diluted using 1% peptone solution according to the serial dilution procedure. A series of dilutions from 10^{-1} to 10^{-9} was prepared for each raw milk sample and then standard total colony count method was applied. Acidity and pH values of the samples and milk loading and unloading time of bowser was recorded to find out the storage time of raw milk in the bowser.

Factors at Field Level Affecting the Quality of Raw Milk

Farmers were interviewed according to a short structured questionnaire to establish facts about farming and milk handling practices. The interview was conducted with open questions on milk quantity, milking hygiene and milk destination. Sanitary condition of such farms and the way of operation of dairy farmers were observed.

RESULTS AND DISCUSSION

Effect of Time Taken for Transportation on Bacterial Counts of Raw Milk

Mean values of Acidity and Total Colony Count (TCC) of milk sampled from milk bowsers reached to the factory from various

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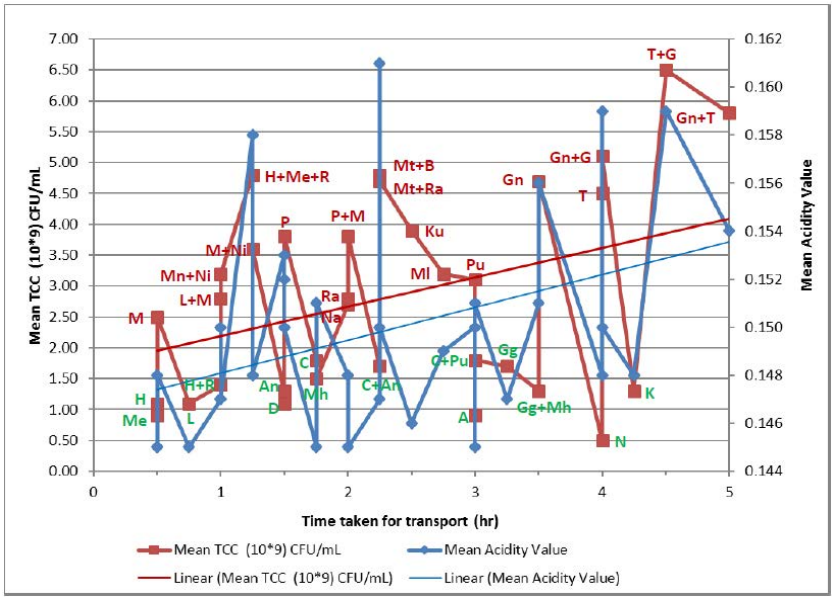
chilling centers were plotted in a graph against time taken to transport **(Figure 2)**.



Note: Centers below the trend line: A - Ampitiya, An - Anamaduwa, C - Chilaw, D - Dodangaslanda, Gg - Galgamuwa, H - Horana, K - Kotagala, L - Loluwagoda, Me - Meepe, Mh - Maho, N – Norwood Centers above the trend line: B - Bulathsinhala, G - Galle, Gn -Gonapinuwala, Ku - Kurunegala, M -Moonamaldeniya, Mn - Minuwangoda, Mt - Mathugama, Ni - Nittambuwa, P - Polgahawela, T - Thihagoda The TCC values for Ml - Matale, Na – Nat,hthandiya, Pu - Puttalam and Ra - Rathnapura were very close to or on the trend line.

Figure 2. Relationship of the mean TCC and Acidity of raw milk with the time taken to transport.

According to **Figure 2**, there is a considerable relationship between the total colony counts of raw milk sampled from milk bowsers with the time taken to transport.

Milk holding temperature and the length of time milk in storage before testing and processing allow bacterial contaminants to multiply. Proving that point, higher microbial density can be observed in raw milk sampled from bowsers with long period of storage as indicated by increasing trend line.

Although there is a tendency of higher TCC and higher acidity being resulted in by longer time for transportation, the statistical correlation (r2=0.495) between these two parameters is poor **(Table 1)**.

Table 1. Correlation of the total colony counts of raw milk reaching the factory and milk holding time during transport.

Correlations				
		Count	**Acidity**	**Holding Time**
Count	Pearson Correlation	1	0.621”	0.495”
	Sig. (2-tailed)		0.000	0.003
	N	34	34	34
Acidity	Pearson Correlation	0.621”	1	0.421’
	Sig. (2-tailed)	0.000		0.013
	N	34	34	34
Holding Time	Pearson Correlation	0.495”	0.421’	1
	Sig. (2-tailed)	0.003	0.013	
	N	34	34	34

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

The data show that several chilling centers with less holding time have considerably high density of bacteria. According to the **Figure 2**, less bacterial counts were recorded in A - Ampitiya, K -Kotagala, N -Norwood and Gg -Galgamuwa areas after 3 hours compared to Na -Naththandiya, P -Polgahawela, Ra -Rathanapura, C -Chilaw, N -Nittambuwa, M -Moonamaldeniya and Mn -Minuwangoda that take two hours or less. This observation can directly be related to the sanitary conditions at the field level. A sample data on field level survey is given in **Table 2** and discussed below.

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Table 2. Data gathered from selected chilling centers through the questionnaire (a sample).

Factors	Nittambuwa	Ruwanwella	Thihagoda	Ampitiya
General Information				
Time of Milking	Once a day 0730 h-0800 h	Once a day 0630 h-0700 h Some farmers do both morning and evening milking	Once a day 0730 h-0800 h	Both morning and evening milking 0400 h-0430 h 1630 h-1700 h
Type of Milking	Manual Milking	Manual Milking	Manual Milking	Manual Milking
Wearing gloves during milking	No	No	No	No
Washing hands before milking	Yes	Yes	Yes	Yes
Sanitizing udder and teats before milking	Yes	Yes	Yes	Yes
Sanitizing colleting vessels and buckets before milking	Yes	Yes	Yes	Yes
Washing udder and removing residual particles attached to teats after milking	Yes	Yes	Yes	Yes
Cleaning of lactating cow	Once in three/ four days	Once a week	Once a week	Once a day
Nutrient Management				
Type/ types of food supplied	Any type of grass and sometimes vitamins	Any type of grass and sometimes vitamins Some of them supply recommended high quality grasses	Any type of grass and sometimes vitamins	Recommended grasses and additional nutritional food and vitamins
Supplement of grass	Allow them to roam and feed	Allow them to roam and feed	Allow them to roam and feed	High quality grasses supplied by farmer
Health Management				
AI treatment	Some used AI method once a year. But most of them do not apply AI	Used AI method once a year	Some used AI method	Used AI method once a year
Discussing the quality of your milk with the field representative	Yes	Yes	No	Yes
Discussing with the veterinarian about the common diseases of herd	Yes	Yes	No	Yes
Type of medicine that used for mastitis	Vaccination	Vaccination	Vaccination	Vaccination and traditional Medicines
Sanitary Condition				
Using of a shelter for lactating cows	No	Mostly without shelter	No	Yes
Type of its floor	-	Soil	-	Cement/ Concrete
Ensure the cleanliness of udder from manure and waste management system	No	No	No	Yes
Restriction of cattle access to manure storage or manure run off	No	No	No	Yes
Conditions of the Chilling Center				
Average temperature of the environment	Pleasant	Pleasant	Hot	Cool
Quality of raw milk				
Fat	4.50	4.31	4.35	4.50
SNF	8.43	8.34	8.40	8.28
Acidity Value	0.150	0.145	0.155	0.145
LR	26.2	26.7	26.9	26.4
KQ	5	6	5	6

Bacterial contamination can generally occur from three main sources; within the udder, outside the udder, and from the surface of equipment used for milk handling and storage [3]. Cow health, environment, milking procedures and equipment sanitation can influence the level of microbial contamination of raw milk. He further explains that these factors will influence the total bacteria count and the types of bacteria present in raw bulk tank milk.

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Observing the transport system of raw milk from milk chilling centers to MILCO factory, sometimes insulated tanks have mixture of raw milk from two or three centers. This also led to increase the colony count of raw milk. As an example, according to the results in **Figure 2**, raw milk from both Horana and Meepe was unloaded with the acidity of 0.145 and their Total Colony Count was 1.1×10^9 cfu/ml and 9×10^8 cfu/ml, respectively. When it was transported after mixing with raw milk in Ruwanwella center, its acidity had risen up to 0.158 and colony count increased up to 4.8×10^9 cfu/ml. That means due to the mixing of lower quality raw milk with high quality centers, quality of milk in bulk tank may be adversely affected. If the company has sufficient facilities to transport raw milk of different centers separately, it will reduce the increase of bacterial count during transport.

Factors at Field Level Affecting the Quality of Raw Milk

According to the results depicted in **Figure 2**, time taken for transport of chilled milk is not the only factor which affects the bacterial count of raw milk sampled from various chilling centers. The deviations from the general trend of lowering of milk quality with time taken in transportation could be related to results obtained through the questionnaire. The results conclusively demonstrate that some field level practices directly influence on the quality of raw milk.

Most farmers particularly those in up country areas such as Ampitiya, Kotagala and Norwood and Galgamuwa in the North-central Province follow recommended practices in cattle farming. The milk samples from those centers were in standard qualities with low bacterial density, low acidity and good Fat and SNF values. Farmers in up country always use a shelter for their herd with good sanitary conditions. The floor of the shelter had been constructed in cement or concrete and separate tanks were prepared for water and fodder of each cow. High quality grasses such as *Brachiaria brizantha*, NB 21, Thiththa kola (*Tithonia diversifolia*) and recommended vitamins with proper dosage aresupplied to the herd. Farmers in Galgamuwa also follow satisfactory level practices.

The practices followed in cattle farming in other areas like Galle, Gonapinuwala and Thihagoda in Southern Province, Horana, Loluwagada, Matugama, Minuwangoda, Meepe, Nittambuwa and Ruwanwella in Western Province, Moonamaldeniya, Polgahawela and Kurunegala in North Western Province, Rathnapura in Sabaragamuwa province were not in accordance with those recommended procedures. Farmers in those areas are not fully engaged with cattle farming. This was a subsistent income source generated, in majority of cases, by house wives, while their husbands are employed. As such sufficient attention is not given to cattle farming in these areas. This causes in poor quality milk at the factory, despite the proximity to the factory as compared to milk received from upcountry farms. Milk receiving from Horana, Loluwagoda, Meepe and Ruwanwella are good in quality, probably because the bowsers reach the factory within an hour.

Considering the microbiological quality of milk reaching the factory after 1 hour of transport following observations were made. Out of the nine samples that took more than 1 hour for transport from North-Western province, only Kurunegala and Polgahawela samples were above the trend line. All the chilling centers in North-Western Province are in either dry zone or intermediate zone. Horana, Loluwagada and Meepe samples from Western Province reached factory in less than 1 hour and showed good microbiological properties. However all other samples (04 numbers) from Western Province and also all samples (03 numbers) from Southern Province showed inferior quality by positioning above the trend line in **Figure 2**. All these chilling centers are in Wet Zone. The samples from Ampitiya, Kotagala and Norwood in Central Province showed best quality as depicted by highest deviation below the trend line, despite the long time taken for transport. It is also noteworthy that these are the placed approximately 1900 ft, 4100 ft and 3600 ft above mean sea level (msl) and cooler climatic conditions. Matale in the same province was located very close to the trend line. The elevation of this location is approximately 1180 ft above msl. Ampitiya is in the intermediate zone while other three are in the wet zone.

The foregoing discussion leads to the conclusion that best quality milk is produced in the Central Province and in areas where there is cooler climate. The climate would have forced the farmers to follow the good management practices in rearing cattle. Despite the hot climate, the North-Western province, in general, produces good quality milk whereas the quality of the milk in Western and Southern provinces is inferior to milk from other sampling locations. It is noteworthy that wet zone areas, with the exception of cooler areas, resulted in poor quality milk.

As discussed below, it is also these areas where good management practices are not observed. Therefore it is recommended that the farmers be encouraged to follow such practices through government and private companies which collect milk from these farmers.

Cattle farmers in these areas do not use shelters for their herd and allow them to go and find their food **(Table 2)**. Because of this free living life style, instead of having access to high quality grasses, they depend on any type of edible grasses. This leads to low nutritional supplement, and thereby quality of raw milk may be reduced. Sanitary conditions of those cows are poor due to their free living life style and the chance of getting diseases is high.

Cattle farmers in Ruwanwella and Kurunegala used shelters for their herd, but these are of substandard conditions (**Table 2** – Type of floor). Floor of the shelter consists with soil and that causes the udder contamination of lactating cow. Absence of a drainage system for the removing of waste materials causes the contamination of the body, especially udder and tail with manure when the cows are resting in their shelters [6]. This leads to high initial bacterial count of raw milk from those herds. The sanitary

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conditions maintained by the milk farmers in Anamaduwa, Chilaw and Galgamuwa ranged from poor to good, resulting in milk with fairly good quality at the receipt of the factory.

Most of the farmers in Ampitiya, Ragala, Norwood and Kotagala restrict cattle access to manure storage or manure run off and ensure the cleanliness of cattle's udder from manure and waste products. They clean their lactating cow once per day and at the same time the shelter is also cleaned. This practice reduces the probability of contaminations.

Considering the health of the cows, farmers in all centers gave vitamin supplement and vaccine to their lactating cows. Artificial insemination (AI) is refused by farmers in Kotagala, Nittambuwa and Chilaw areas as, according to them, this practice results in more male calves which becomes a burden for them. This issue is not identifies as a major concern and therefore it is recommended to carry out proper research into this aspect and to find a suitable solution.

In addition to that, cows suffering from mastitis normally separated from healthy ones to avoid the spreading of disease to others.

Farmers were able to identify the mastitis disease and used both vaccination method and traditional methods to cure it **(Table 2)**. During that period milking is done at least once per two hours but not bulk with milk of healthy ones. All farmers who were involved with this field survey are well educated of those points. However their knowledge on the importance of sanitary conditions in improving the quality of their milk was not adequate. A better awareness on use of shelters with standard conditions in order to reduce bacterial contaminations must be implemented.

The Department of Agriculture as well as dairy industry can take steps in educating the farmers in producing high quality raw milk at field level.

By giving loans or material such as cement, bricks, sheets and etc., farmers can be encouraged to use shelter for their herd. This same procedure has been applied successfully in Kotagala and Ragala areas and because of that almost all farmers use shelters for their herd **(Table 2)**.

Quality of raw milk also depends on time of milking and mode of transport. In the areas of Galle, Thihagoda, Polgahawela, Horana, etc. milking was done only in the morning from 0700 h to 0800 h. The elevated ambient temperature at the late morning may also contribute to higher bacterial counts. Milking is done both the morning and in the evening at Norwood, Ampitiya, Welimada, Kotagala etc. As shown in **Table 2**, morning milking starts at about 0430 h – 0530 h and cool condition of the environment at that time may be a factor in reducing the bacterial counts in raw milk.

Most farmers did not tie the cow's tail during milking, had no appropriate milking place, milked animals on treatment, did not wash hands before milking, did not cover the milk and had no clean (boiled) water for washing hands and utensils. These improper field practices of farmers also cause for the increasing of initial bacterial count of raw milk [7]. He further explained that tying of the tail is important because cows carry a lot of dust or mud on their body. During milking, a lot of this dust is dislodged by the constant waving of the tail to drive way flies. This constitutes one of the most direct methods of milk contamination.

Results in **Table 2** show that all farmers interviewed through this questionnaire did manual milking. When cows are milked by hand, bacteria can get into the milk via the milker, the cow, the litter and the ambient air. The magnitude of the influx depends largely on the skill and the hygiene-consciousness of the milker and the way the cow is managed [7]. Most of these sources of contamination are eliminated in machine milking. However, a very large number of bacteria can enter the milk this way if the milking equipment is not cleaned properly.

The degree of contamination and the composition of the bacterial community depend on the cleanliness of the cow's environment and the cleanliness of the surfaces with which the milk comes into contact, e.g., The pail or milking machine, the strainer, the transport churn or the tank and agitator. Milk-wetted surfaces are usually a much greater source of contamination than the udder [8].

Just after milking, milk should be transported to chilling centers for proper cooling. Time which spend for that is very important because less time lead for less bacterial count and good quality raw milk. Milk should be stored in insulated containers with proper sanitary conditions during this transportation. It was however observed that most of farmers do not pay attention in this regard. Although the farmers claimed that they clean their collecting buckets, there were residual milk particles attached inside the bucket. That causes the formation of biofilms and increasing of total colony count of raw milk. Biofilms not only become continuous sources of contamination, but also are extremely difficult to remove [9].

There is no tested and recommended method for removal of biofilms from surfaces of equipment in which milk is kept, except sonication which is not practical at small hold farmer level [10,11]. There is, therefore, an opportunity and necessity for research on how to minimize biofilm formation and how to remove these from utensils used in milk industry [12]. Proper education and instructions should be given to the farmers and a trained worker may be employed at the milk collection center for supervision of cleanliness of the containers.

In addition to above reasons, environmental conditions also affect the quality of raw milk at the field level [13]. Having cooler

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conditions in the up country than in other area may be a reason for less bacterial count of raw milk collected from those areas. With the increasing of environmental temperature, bacterial count also increased. According to the results in **Table 2**, Galle, Thihagoda, Kurunegala and Naththandiya areas experience hot climatic conditions and that will increase the growth of bacteria resulting higher bacterial density in raw milk.

The results of this study show that to ensure supply of best quality milk for consumers, first steps should be taken at field level. Farmers should have good education of cattle farming and how to avoid contaminations and resulting in high quality raw milk. Majority of the farmers interviewed were not satisfied in cattle farming as the income generated by this activity is low in comparison to the time and effort they invest. This is one of the reasons for lethargy shown by them in maintaining expected level of hygiene in their farms. To get their active participation for this industry, a number of steps need to be taken. An attractive welfare system including an insurance mechanism will certainly boost their enthusiasm as they will feel secured. High quality lactating cows should be given to those who have been identified as having high potential to become good milk farmers through proper studies. Adequate land for growing high quality fodder is essential.

Another interesting observation done in this study is that distribution of the sampling points above and below the trend lines. All locations, except Kurunegala, which show lower quality milk are scattered in wet zone of the country, where as those that produce good milk are in up country and dry zone **(Figure 1)**. Horana, Loluwagoda, Meepe and Ruwanwella are in the wet zone, but the time taken for transport is minimal for these locations. Therefore any effect on the microbial load by sanitary factors or climatic region could be masked due to low incubation time.

CONCLUSION

The number of bacteria remaining in raw milk reaching the processing factory from the small-hold farmers shows a positive trend with its milk holding time in transportation. However field practices were identified as a major contributing factor for microbial load and acidity level and hence the control of microbial density in milk collected from small scale farms should begin at the field level by maintaining proper sanitary conditions. In order to achieve this farmer education is essential and proper and regular inspection monitoring is necessary. As the insecure feeling in people engaged in milk farming was apparent, proper welfare scheme is recommended to boost the enthusiasm of farmers towards their occupation. Good quality lactating cows and adequate land for good quality fodder production should be provided to carefully selected farmers to enhance their income, in order to engage their full potential for the farming following good practices. The reasons and remedial measures need to be identified for the observation that wet zone of Sri Lanka produces lower quality milk with reference microbiological properties.

REFERENCES

1. Attia H, et al. Dromedary milk lactic acid fermentation: Microbiological and rheological characteristic. J Ind Microbiol Biotechnol. 2001;26:263-270.
2. Cousin MA. Presence and activity of psychrotrophic microorganisms in milk and dairy products. J Food Prot. 1982;45:172-207.
3. Gouranga CC, et al. Microbiological profile of the traditionally collected industrial raw milk from the milk pocket zones of Bangladesh. Bangladesh J Microbiol. 2008;25:17-20.
4. Barbano DM, et al. Influence of raw milk quality on fluid milk shelf life. J Dairy Sci. 2006;89:E15-19.
5. DAPH Annual report. Department of Animal Production and Health of Sri Lanka. 2014.
6. Teo AYL and Stephen KJ. Development of a simple recovery-enrichment system for enhanced detection of heat-injured Listeria monocytogenes in pasteurized milk. J Food Prot. 2000;63:462-472.
7. David WF, et al. Pasteurized milk as a vehicle of infection in an outbreak of listeriosis. N Engl J Med. 1983;312:404-407.
8. Grimaud G, et al. An evaluation of milk quality in Uganda, value chain assessment and recommendations. Afr J Food Agric Nutr Dev. 2007;7:716-728.
9. Parkar SG, et al. Evaluation of the effect of cleaning regimes on biofilms of thermophilic bacilli on stainless steel. J Appl Microbiol. 2003;96:110-116.
10. Ravanis S and Lewis M. Observations on the effect of raw milk quality on the keeping quality of pasteurized milk. J Appl Microbiol. 1995;20:164-167.
11. Marchand S, et al. Biofilm formation in milk production and processing environments; Influence on milk quality and safety. Compr Rev Food Sci Food Saf. 2012;11:133-147.
12. Arimi SM, et al.Diversity of Listeria ribotypes from dairy cattle, silage and dairy processing environments. J Food Prot. 1997;60:811-816.
13. Hassan AN and Frank JF. Encyclopedia of Dairy Sciences. Athens. 2nd edn. 2011;447-457.