

Hygienic practices and quality of raw milk produced in a small scale dairy farming area in Sri Lanka

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Abstract- Sri Lankan domestic dairy production has shown a significant improvement in recent years but less attention is given for milk quality and hygienic practices. This study focused on evaluating the common hygienic practices and the quality of raw milk produced in Makandura (NWP) area. A total of 75 raw milk samples were collected from dairy farmers from three milk collecting centres (MCC), Mahayawatta(MW); n=33, Makandura town area (MKT); n=22 and Pahala Makandura (PM); n=20, during the period from June to August 2013. All the samples were subjected to physicochemical, microbiological, platform, and keeping quality tests. Meanwhile all the farmers were interviewed using a pre-tested questionnaire to assess hygienic practices. There was no significant difference ($p>0.05$) in all physicochemical quality parameters except Specific Gravity (SG) and Solid Non Fat% among milk received from three MCCs. The mean SG and pH values reported from all MCCs were within the acceptable ranges. There were significant differences ($p<0.05$) in microbiological quality parameters among three MCCs and all of them were lower than the standards with highest counts reported from PM. Simultaneously, PM had the highest percentage of abnormalities in organoleptic qualities and the highest percentage of positive results from Alcohol test, clot on boiling test and Resazurine ten minutes test. Few farmers carried out recommended hygienic practices including post milking teat dipping (0% in all three MCCs), complete milking (MW,18%, MKT,23%, PM,16%) and fore milk rejection (MW,7%, MKT,23%, PM,5). Appropriate hygienic management practices must be practiced during all the stages of dairy production in order to improve the milk quality.

Index Terms- Hygienic practices, Microbiological quality, Physicochemical quality, Raw milk

I. INTRODUCTION

In parallel to increasing demand, domestic dairy production has also shown a phenomenal growth during past two three years, mainly due to positive government involvement which encouraged local milk production (Department of Animal Production and Health 2014). According to the Central Bank report in 2015, total annual milk production from cattle and buffalo in Sri Lanka was 374.4 million litres, an increase of 12.1% over the previous year. Since domestic milk production is sufficient only to meet 40% of the national requirement, Rs. 31.842 million valued milk powder (81.759 MT) has been imported in 2015 which marked 21.7% increment compared to 2014 (Central Bank of Sri Lanka 2015). Consumers are also

taking a greater interest in the hygienic quality and safety of milk.

Milk quality is an important aspect that determines whether it is fit for human consumption or further processing. Physicochemical and microbiological quality parameters are used to determine its nutritional value and suitability for production of dairy products (Fox and MacSweeney 1998). Rapid tests at receiving points are normally used to decide whether to reject or accept the milk.

As raw milk is a rich source of nutrients, it provides favourable conditions for rapid growth and survival of several pathogenic microbes such as *Salmonellaspp*, *Campylobacter jejuni*, *Staphylococcus aureus*, pathogenic *Escherichia coli* strains, Hepatitis A while spoilage microorganisms include *Streptococcus lactis*, *Lactobacillus spp.* and *Acinetobacterjohnsoni*(Black 2004). These may derive from cow's udder and body or may enter from milk handling equipment, human handlers, air, soil, feed and pests such as flies and rodents (Hill 1952). The previous studies of milk quality from different areas of Sri Lanka revealed that microbiological quality is quite variable and often substandard (Deshapriya et al. 2004 and 2007; De Silva et al. 2016; Vairamuthuet al. 2010). The best way to ensure adequate microbiological quality and safety is by strict control and maintenance of hygiene at all stages of milk handling coupled with improved personal hygiene of milk handlers.

Kurunegala, is one of the important agricultural districts of Sri Lanka and is recognised for its coconut plantation, paddy cultivation and livestock industries. The dairy production in the Kurunegala district accounts for approximately 21% of the total domestic milk production (Department of Animal Production and Health 2014). According to the information given by the regional office of Department of Animal Production and Health – Pannala, Makandura livestock development instructor's (LDI) area has a significant number of small scale dairy farmers who produce around 292,000 L of milk per year.

The objective of this study was to assess the physicochemical and microbiological quality of raw milk, to identify the common hygienic practices which can directly affect the quality of raw milk received to milk collection centres from small scale dairy farmers in the Makandura area of Kurunagala district of Sri Lanka and to provide appropriate recommendations to improve milk quality via encouraging clean milk production.

II. METHODOLOGY

Initially 75 raw milk samples were collected from dairy farmers supplying three milk collecting centres, Mahayawatta (MW), Makandura town area (MKT) and Pahala Makandura (PM) in Makandura area, during the period from June to August 2013. Duplicate samples were collected, one for microbiological studies and the other one for keeping quality, platform tests and physiochemical evaluation. Samples for microbiological studies were collected into labelled, sterilised glass bottles (50 mL) and other samples were collected into labelled, properly washed glass bottles (100 mL). Each raw milk supply container was thoroughly mixed to disperse the milk fat before taking samples. All the farmers were interviewed using a pretested questionnaire to assess their socio-economic background, hygiene and other management practices including feeding. Temperature and lactometer readings of each milk sample were measured directly at the sampling point using a thermometer and a lactometer, respectively. Samples for microbiological analysis were frozen until needed.

Platform tests

Raw milk samples were screened using the Resazurin 10 minutes test (Davis 1994), the alcohol stability test using 68% (v/v) ethanol solution and a clot on boiling test (Roy and Sen 1991). Evaluation of organoleptic qualities (taste, appearance and odour) was done immediately after samples were delivered to the laboratory.

Adulteration tests

This study focused on the presence of starch, salt and hydrogen peroxide, which are considered as common adulterants in Sri Lankan raw milk.

Detection of starch in milk

Around 10 mL of milk were pipetted into a test tube and 4-6 drops of 1% (w/v) iodine solution was added. The contents were mixed gently and after few minutes the colour at the bottom of the test tube was observed. The presence of dark blue or black particles indicated that starch has been added (Sacheti 1998).

Detection of salt in milk

One millilitre of milk was transferred to a clean test tube and two drops of 10% (w/v) potassium chromate solution and one

III. RESULTS AND DISCUSSION

Socio economic background

The dairy sub-sector in Sri Lanka mainly consists of small dairy farmers (Perera and Jayasuriya 2008). Only 40% of surveyed farmers in the Makandura area were involved in dairy production as their primary source of income, so dairy farming can be considered as an important secondary livelihood in this rural area. Similarly, 86% of these dairy farmers were categorized as small-scale producers, in which a farmer owned less than five cattle while the remaining 14% were identified as medium-scale farmers (owning 5-10 cattle).

Most of the farmers (63%) had more than two years' experience in dairy farming and 44% had participated in some kind of training session on dairy production. Background education was adequate, as 72% of dairy farmers had studied up to General Certificate of Education (GCE) Ordinary level and 16% had gone

millilitre of N/20 silver nitrate solution were added. Finally, sample was shaken well and colour change was observed (Sharma et al. 2012).

Detection of Hydrogen peroxide in milk

Around 10 mL of milk was measured to a test tube and 1 mL of 10% (w/v) KI solution was added. Then 10 mL of concentrated hydrochloric acid was added and the mixture held for three minutes in room temperature. A blue-black colour indicated the presence of peroxide in milk.

Physiochemical tests

Specific gravity was determined by lactometer, correcting for the milk temperature. Fat was measured by the Gerber method (James 1961) while total solids (TS) and solids-not-fat (SNF) contents were calculated according to Spreer (1998). The pH value of milk samples was measured using a calibrated digital pH meter (OHAUS, Parsippany, USA).

Microbiological tests

Samples for microbiological analysis were thawed out then serially diluted with peptone water (OXOID, Hampshire, England) to prepare a 10⁻¹-10⁻⁵ dilution series. For total plate counts appropriate dilutions (10⁻³, 10⁻⁴, and 10⁻⁵) were placed on plate count agar (HIMEDIA, Mumbai, India) using a pour plate method. Inoculated plates were incubated for 24 hours at 37°C. Developed colonies were counted using a manual colony counter and expressed in colony forming units per millilitre (CFU/mL). The two-tube most probable number (MPN) technique was performed to enumerate coliforms in milk, following a two-step incubation procedure. The presumptive test used was MACKONKY broth (HIMEDIA, Mumbai, India) and tubes were incubated for 48 hours at 37°C. Brilliant Green Bile broth (BGBB) (HIMEDIA, Mumbai, India) was used for the confirmation test for faecal coliforms, with tubes incubated at 44°C for 48 hours. Aseptic procedures were followed during all microbiological analyses.

Data handling

Data obtained from the laboratory analyses and questionnaires were entered into MS EXCEL and analysed using Minitab 15.

on to GCE Advanced level. This supported the proposition by Vairamuthu et al. (2010) that farmers could be educated about recommended management practices, the importance of sustainable dairy farming and maintaining the required quality of raw milk

Dairy management system

Extensive management was commonly practiced (96%) with only 4% of farmers adopting a semi-intensive system. Jersey and Jersey crosses accounted for the majority of the cattle population in this area. Most of the dairy farmers (78%) provided some form of housing for animals, mainly poor quality night sheds (92%). Few farmers used tie stalls (6%) or loose housing (2%). Free or tethered grazing was practiced under the trees in coconut plantations. Most animals were fed with cut grasses, crop residues and agricultural byproducts. Few farmers practiced

feeding cut grasses during the night along with grazing in daytime and the majority of the animal diets were supplemented with commercial feed, broken rice, rice polish and other byproducts that were available in the village. Some farmers had started to develop improved grass beds with the support of the government extension service. Hand milking was predominant and farmers were reluctant to move to machine milking since it required high capital investment and technical skills(Vairamuthu et al. 2010)

Hygienic practices

Milk let down from a healthy cow’s udder is virtually free from microorganisms but is readily contaminated. So it is essential to follow hygienic management practices. It is widely accepted that milking, storing and transporting equipment, milking area, exterior of the cow’s udder and the milker are the most common routes of contamination (Pandey et al. 2014).

Table 1 gives a summary of the cleaning practices in areas covered by the three milk reception stations. Cleaning of milking equipment was widely practiced though methods of cleaning varied. Pandey et al. (2014) identified that application of appropriate disinfectants such as iodophores in cleaning milking equipment markedly reduced the bacterial counts but none of the farmers from these areas used disinfectants in cleaning milking utensils. Acceptable stainless steel containers were commonly used for milk transport (MW=81%, MKT=73%, PM=54%) while a considerable amount of glass (9%) and plastic bottles (28%) were also used in PM. Cleaning of plastic and glass bottles is difficult due to the narrow neck restricting access. Microorganisms can easily grow in moist milky residues in such bottles (Donkoret al. 2007; Kuma et al. 2015).

Cleaning the milking area was not popular in PM where milking was generally done outdoors in the shade of a tree. This practice was also widely followed in the other areas. Most of the farmers (92%) had no separate milking area and almost all farmers who reared animals in tie stall barns (6%) milked in the rearing area, which was cleaned several times per day, especially before milking.

Table 1. Use of different milking area and equipment cleaning regimes among farmers from MW, MKT

Parameter	Percentage (%)		
	MW (n=33)	MKT (n=22)	PM (n=20)
Frequency of cleaning milking equipment			
Several times	16	6	10
Only before milking	16	11	36
Before and after milking	68	83	50
Not at all	0	0	0
Some times	0	0	4
Method of cleaning			
With clean water and detergent/soap	30	49	6
Only with clean water	36	29	72
Only with poor quality water	16	10	16

water			
Hot water and steam	18	12	6

Frequency of cleaning milk storage and transportation equipment

Only before using	24	12	21
Before and after using	76	88	79
Not cleaning at all	0	0	0
Some times	0	0	0

Method of cleaning

With clean water and detergent/soap	74	70	49
Only with clean water	12	23	34
Only with poor quality water	2	2	9
Hot water and steam	12	5	8

Frequency of cleaning milking area

Several times	2	2	3
Only before milking	64	66	64
Before and after milking	2	30	15
Not cleaning at all	4	1	5.5
Some times	28	1	12.5

Method of cleaning

With clean water and detergent	9	10	14
Only with clean water	10	52	5
Only with poor quality water	10	21	28
Sweeping	46	13	20
Not at all	25	4	33

In MKT, 75% of the farmers used deep wells as the primary water source and no-one had access to chlorinated tap water. Around 22% of farmers used a nearby stream as their main water source for the dairy units. As an area with extensive paddy cultivation, those streams were irrigation canals for paddy fields and there was a high risk of contamination with agrochemical residues.

Regardless of the area a significant proportion of dairy farmers were not adapted to use the recommended hygienic practices during milking, e.g. wearing special clean clothing, separation of infected animals, following milking order, foremilk rejection and complete milking as indicated in Figure 1. Farmers from PM were reported to have less concern to use hygienic practices than farmers from the other two areas. Even though a considerable proportion of farmers from all three areas (MW=43%, MKT=51%, PM=29%) stated that they wear special clean clothing for milking, they don’t wear the gloves, boots and coats that were recommended to use.

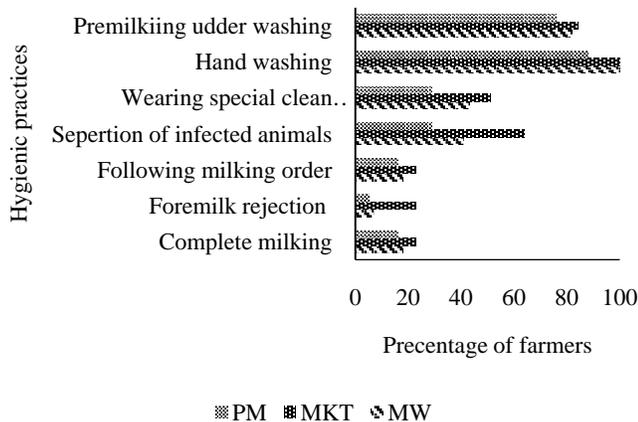


Fig 1. Use of preliminary hygienic measures during milking

Washing hands before milking was commonly practiced in all three areas but method and frequency differed. Accordingly, 24%, 6% and 6% of farmers from MW, MKT and PM stated that they washed their hands several times (inter-cow hand washing). It should be highlighted that 12% of farmers from PM did not wash their hands even before milking. In contrast, farmers from MKT and MW areas showed a positive concern towards hand washing as almost all washed their hands at least before milking. Most of the respondents (MW=82%, MKT=84%, PM=76%) implemented pre-milking udder washing with water, which was not followed by drying or wiping the udder. None of them used soap, detergent or any type of disinfectant for udder washing and this cannot be considered as sufficient cleaning Vairamuthuet al. 2010). Pre-milking udder preparation and teat disinfection play important roles in reducing bacterial counts in milk (Galton et al. 1984). Ineffective udder cleaning can be one of the important contributors to poor hygienic quality. Pre-milking udder washing was not practiced by the farmers who let the calf to suckle before milking since they believed that it helped to increase milk let-down and the teats get washed by the saliva of calf and there was no need to wash the udder before milking.

According to the farmers' responses, pest and disease problems that can affect the milk quality were not common in this area during the study period. However, none of the farmers used the strip cup test, the simplest method to detect early stages of clinical mastitis (Campbell and Marshall 2016). Some, 19% of the farmers surveyed had followed a milking order which was not based on the status of mastitis but milk production.

As with other studies (Millogo et al. 2008; Vairamuthu et al. 2010) none had adopted post milking teat dipping, the single most effective practice for reducing mastitis infections, as well as the total microbial load (Kamal and Bayoumi 2015).

Platform tests

Milk from PM was found to have the highest percentage of samples failing the COB, RTMT and alcohol tests, as shown in Figure 2. RTMT is mainly used to assess the freshness and hygienic quality of milk. In MKT, milk was only collected once a day but almost a quarter of the farmers (23%) milked twice daily. The evening milk was placed in a refrigerator overnight then mixed with the morning milk and taken to the milk

collecting centre. The farmers from MKT have been advised to deliver the morning and evening milk separately.

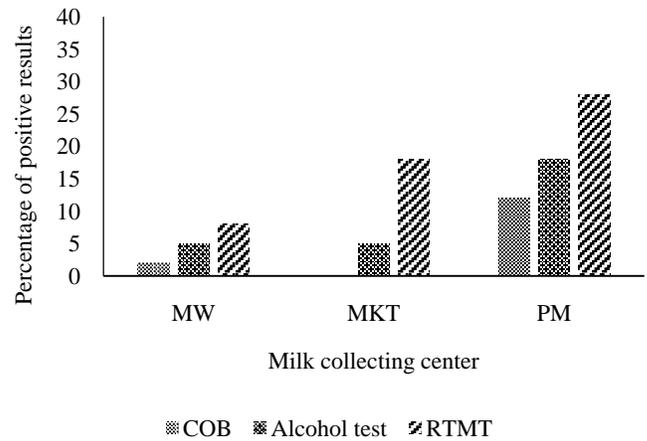


Fig 2. Percentage of milk samples from MW, MKT and PM showing failures for RTMT, COB and alcohol tests

Evaluation of taste, appearance and odour permits rapid segregation of poor quality milk at the milk receiving platforms. Accordingly, each and every milk container was tested in order to decide acceptance or rejection at all three milk collecting centres. Doubtful milk was kept and transported in a separate container to prevent contamination of other milk. As shown in Figure 3, PM had the highest percentage of sensory abnormalities. The presences of dirt particles, slightly sour taste and the smell of cow dung were noted as the most common abnormalities. This may be due to poor hygiene in milk handling plus a prolonged holding time prior to delivery, providing a favourable environment for microbial growth (Islam et al. 2013).

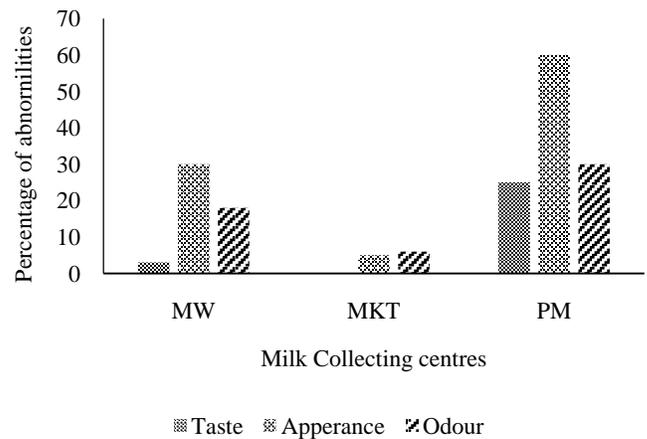


Fig 3. Percentage of samples from three areas showing sensory abnormalities (Taste, appearance and odour)

Adulteration

Raw milk adulteration is a serious and persistent issue in most developing countries (Abbas et al. 2013;Barham et al. 2014; Mahmoudi et al. 2015). In this survey however, not a single sample was positive for any of the adulterants. Similar results has also been found in other studies (Hossain and Dev 2013; Islam et al. 2013; De Silva et al. 2016).

Physicochemical and microbiological quality

There were no significant differences ($p>0.05$) between the physicochemical quality parameters except for SG and SNF, as shown in Table 2. The mean fat and SNF percentages reported from all three milk collecting centres were within the acceptable range (Food Act no 26 1980). This may be achieved by quality breeding materials and proper nutrition management. The fat, SNF and TS percentages in the present study were higher than the percentages reported by Kittivachraet al. (2006) in Thailand but lower than the values reported by Dehinenet al. (2013) in Ethiopia.

Table 2. Physicochemical and microbiological quality of raw milks

Quality parameter	Milk collecting centre		
	MW Mean± SD (n = 33)	MKT Mean± SD (n = 22)	PM Mean± SD (n = 20)
Physicochemical quality			
Specific gravity	1.034±0.002 ^a	1.032±0.002 ^b	1.034±0.002 ^a
Total Solid (% w/w)	13.67 ± 1.0 ^a	13.3±1.3 ^{a,b}	13.7 ± 1.0 ^a
Fat (% w/w)	3.6 ± 0.6 ^a	3.8 ± 0.8 ^a	3.6 ± 0.6 ^a
Solid Non Fat (% w/w)	10.0 ± 0.5 ^a	9.5 ± 0.6 ^b	10.0 ± 0.5 ^a
pH	6.60±0.366 ^a	6.64±0.436 ^a	6.69±0.531 ^a
Microbiological quality			
Total Plate Count (x10 ⁶ cfu/mL)	1.2 ± 1.8 ^a	0.4 ± 0.4 ^b	5.4 ± 6.5 ^c
Total Coliform Count (MPN cfu/mL)	58 ± 43 ^a	29 ± 37 ^b	72 ± 34 ^c
Faecal Coliform Count (MPN cfu/mL)	36 ± 33 ^a	22 ± 31 ^b	51 ± 42 ^c

Means that do not share a same letter are significantly different ($P>0.05$), n = sample size, SD = Standard deviation, MPN = Most probable number of bacteria

There were significant differences ($p<0.05$) in microbiological quality parameters between the three milk collecting centres but all of them were below the expected standard of less than 30,000cfu/mL (Sri Lanka Standard Institute 1983). The mean TPC of Makandura (2.3 x 10⁶cfu/mL) was similar to that reported in the study in Jaffna, Sri Lanka, by Vairamuthuet al. (2010). The higher microbial counts may be due to a combination of poor hygiene, inadequate refrigeration and high ambient temperature. The results of the present study were in line with studies done in Sri Lanka (Deshapriya et al. 2004 and 2007) and in other tropical conditions (Lingathurai and Vellathurai 2010; Yuen et al. 2012).

IV. CONCLUSION

Regardless of the differences among the study sites, all showed poor microbial quality when compared to the established national and international standards for raw milk quality. This could be attributed to the cumulative results of inefficient

cleaning and disinfection coupled with poor concern and negligence of farmers towards appropriate hygienic practices. Training programmes on hygienic management and raising awareness of the importance of disease control may contribute to improvements but do not provide the necessary incentive. Currently in Sri Lanka, the major pricing elements are based on specific gravity and milk solids, whereas most of the developed countries follow a milk grading scheme that includes microbiological quality along with other physicochemical parameters to determine the economic value of milk. These more comprehensive payment schemes will be effective in motivating the Sri Lankan farmers to produce better quality milk.

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