

Original Article

Milk postharvest handling practices across the supply chain in Eastern Ethiopia

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ABSTRACT

Objective: This study was conducted to assess hygienic cow milk handling practices of milk producers, traders (informal collectors, transporters and vendors) and consumers across the milk supply chain in the Eastern Ethiopia.

Materials and methods: A total of 160 milk producers in Babile district were selected using multistage stratified sampling technique. Moreover, a total of 54 milk collectors and transporters (5, 40, 9 from Jigjiga, Harar and Dire Dawa town, respectively), 152 vendors (40 from Bable, Harar and Dire Dawa town and 32 from Jigjiga town) and 160 consumers (40 from each town) were selected using snowball sampling technique. Data from the selected actors were collected using focus group discussion, questionnaire survey and observations.

Results: The study revealed that the majority of milk handling operations in the study area is carried out by females. The majority of respondent milk producers (87.5-92.5%), collectors and transporters (88.9-100%), vendors (77.5-90.7%) and some consumers (37.5-47.5%) performing milk handling operations were illiterate. Most of the observed actors in the study area perform malpractices (such as failure to stop milk handling while showing disease symptoms, improper hand washing and handling of risk factors) while working with milk. Majority of respondent milk producers (87.5-97.5%), all traders and some consumers (12.5-32.5%) use plastic containers for milk handling. Milk handling equipments were commonly washed using warm water, detergent and sand; however, in most case they were not properly protected from risk factors after washing. Majority of respondent milk producers (55-65%), collectors and transporters (60-66.7%), and some vendors (0-50%) and consumers (0-55%) use water from non-tap sources for hygienic practices.

Conclusion: In general; the findings indicated that milk handling practices performed across the supply chain in the study area were unhygienic and therefore suggested the need for improving hygienic practices.

KEYWORDS

Cow milk, Hygienic practices, Informal traders, Milk consumers, Milk producers

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INTRODUCTION

Milk is the lacteal secretion of the mammary glands of a mammal and plays an important role in human nutrition throughout the world where it promotes growth and maintenance of body tissue ([Chye et al., 2004](#); [Javaid et al., 2009](#); [Grimaud et al., 2009](#)). It is the most complete food product of animal origin providing more essential nutrients (protein, energy, vitamins and minerals) in significant amounts than any other single food ([Pandey and Voskuil, 2011](#)).

Milk is obtained from cows, camel, goats, and sheep but the most widely used farm animal for milk production is cow ([Bereda et al., 2014](#)). Cow's milk has long been considered as a highly nutritious and valuable human food and is consumed by millions daily in a variety of different products in the world ([Ali, 2010](#)). It is reported that daily consumption of one liter of cow's milk furnishes an average human approximately all the fat, calcium, phosphorous and riboflavin, one third of vitamin A, ascorbic acid, and thiamine, one fourth of the calories, and with the exception of iron, copper, manganese and magnesium, all the minerals needed daily ([Pandey and Voskuil, 2011](#)). Cow's milk is an important component of the diet which is consumed without any taboo across the different parts of the country. It is also an economically important farm commodity and investment option for smallholder farmers in Ethiopia ([Welearegay et al., 2012](#)).

It is well established that consumers want clean, wholesome and nutritious food including milk that is produced in a sound, sanitary manner and is free from pathogens ([Ruegg, 2003](#); [Khan et al., 2008](#)). However, in developing countries, including Ethiopia, the hygienic levels exercised during milk production are key factors affecting the quality of milk mainly the microbial quality ([Zelalem and Faye, 2006](#)). Not only milk producers but also handlers such as collectors and transporters, vendors and consumers play a key role in ensuring the microbial quality of milk across the milk supply chain ([Mattias, 2013](#)). Mishandling and disregard of hygienic measures by milk handling personnel may enable spoilage microbes to come into contact with milk and in some cases to survive and multiply in sufficient numbers to reduce the shelf-life of milk and cause spoilage of milk before it reaches to its final destination ([Chatterjee et al., 2006](#); [Kivaria et al., 2006](#)). High spoilage is reported frequently in milk coming from lowland regions due to high ambient temperatures prevalent in the area combined with lack of cooling facilities as well as transport, scattered distribution of producers and long distance to markets, which make difficult to deliver milk (especially raw milk)

to urban centers ([Lumadede et al., 2010](#); [Terfa, 2015](#)). The hygienic levels exercised during milk handling practices also influence the levels of contamination of raw milk with pathogenic bacteria as well as the types of pathogens present in raw milk and expose consumers to serious milk-borne public health risks like typhoid, paratyphoid, tuberculosis, dysentery, gastrointestinal illness and others ([Hayes et al., 2001](#)).

The potential risk of milk contamination by spoilage and pathogenic microbes, as well as other contaminant agents (such as adulterants and antimicrobial drug residues) is high for milk produced and handled in the informal channels ([Kurwijila et al., 2006](#)). This is because, there is little or no quality control (milk handling practices are done commonly without observing hygienic practices) for milk produced and handled in the informal channels. For example, it is a common practice to handle, transport and vend milk in inappropriate milk holding and storage equipment as well as temperature, especially in developing countries like Ethiopia. Such a practice poses a threat to public health as chances of consuming unsafe milk are very high ([Zelalem, 2012](#)).

To protect milk from spoilage loss as well as consumers from milk-borne public health problems, there needs to be the availability of documented information on hygienic milk handling practices of actors (producers, collectors and transporters, vendors and consumers) across the supply chain. This is because, such information may be important for governmental, non-governmental and other development organizations to undertake relevant development interventions, which make milk producers, traders and consumers to have clear understanding on the hygienic practices essential for safe milk handling. This understanding may be important to ensure safety and suitability of raw milk for its intended use. However, currently there is no documented information available on hygienic milk handling practices of actors across the milk supply chain in the study area where almost all milk produced from pastoral and agro-pastoral areas is mainly supplied to urban areas through informal milk marketing channels. Therefore, the objective of the present study was to assess hygienic cow milk handling practices of milk producers, traders (informal collectors, transporters, and vendors), and consumers across the milk supply chain in Eastern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted across cow milk supply chain in eastern Ethiopia, namely Babile district, Harar, Dire Dawa and

Jigjiga towns (**Figure 1**). Babile district is the site of milk production whereas Harar, Dire Dawa and Jigjiga towns are the sites of milk distribution (by vendors via informal marketing channel) and consumption.

Babile district, one of the 7 districts in East Hararghe zone, is located in the eastern corner of Oromia National Regional State bordered with Gursum, Fedis, Harari and Somali National Regional State. Geographically, it is located at 9°08'N latitude, 42°21'E longitude, and 557 km away from Addis Ababa. The district has an altitude that ranges from 950 to 2000 m above sea level. The mean annual minimum and maximum temperature ranges from 18-28°C while the mean annual rainfall and humidity ranges from 700-900mm and 33-38%, respectively ([CSA, 2008](#)). The district has a total area of 3169.06 km², of which only 21.1% is considered suitable for crop production indicating that it is much of a rangeland where livestock rearing is a major activity. The two prevailing agricultural production systems in the district are pastoral and agro-pastoral production system ([CSA, 2008](#)). Pastoral system is a system in which livestock accounts for over 80% of the total income of the household; whereas, agro-pastoral system is a system in which livestock accounts 50-80% of the total income of the household ([Giuliano et al., 2010](#)). The estimated livestock population in the district indicated that cattle are the most prominent in population size (56355) followed by goat (23020), sheep (12216) and camel (9704) ([BDLDHA, 2015](#)). Daily, the district approximately produces about 12000 and 6745 liters of raw cow's milk during the wet and dry season, respectively ([BDLDHA, 2015](#)). Of the total cow's milk produced daily in the district, about 50% is used for sale and supplied to urban areas of eastern Ethiopia (mainly Babile, Jigjiga, Harar, Aweday and Dire Dawa town), and even exported to neighbouring countries like Somali-land through informal market channels. Almost all fluid milk (both for cow and camel) in the district is marketed through informal marketing channels mainly in fresh (raw) form ([Demissie et al., 2015](#)). The total human population of the district is estimated at 115,229. Out of total human population of the district, about 21.53% (24,814) is found at Babile town ([CSA, 2013](#)).

Harar town is geographically located between 9.11°-9.24° north of latitude and 42.03-42.16° east of longitude and is located at a distance of 526 km east of Addis Ababa and 31 km west of Babile district ([Salih, 2009](#)). It is located at an altitude of 1850 meters above sea level and has a mean annual rainfall and humidity of 596 mm and 60.3%, respectively ([Abebe et al., 2014](#)). The mean annual maximum and minimum temperature of the town is 25

and 10°C, respectively. The total human population of the town is estimated at 125,000 with a growth rate of 2.6% ([CSA, 2013](#)).

Dire Dawa town is geographically located in the eastern part of Ethiopia at 9°36' N and 41°52'E ([Melese and Dutamo, 2015](#)) and is located 515 km away from Addis Ababa and 86 km west of Babile district. The area is situated at 1200 meters above sea level, and has a mean annual rainfall and humidity of 594 mm and 41.82%, respectively. The mean annual maximum and minimum temperatures of the town are 31.4°C and 18.41°C, respectively ([Mumed and Eshetu, 2015](#)). The total human population of the town is estimated at 288,000 with a growth rate of 2.5% ([CSA, 2013](#)).

Jigjiga town is the administrative capital of Ethiopian Somali Regional State. Geographically, it is located approximately 628 km east of Addis Ababa, 74 km east of Babile district and 60 km west of the border with the Republic of Somali-land. The town has an altitude of 1609 meters above sea level, and a latitude and longitude of 9°21'N and 42°48'E and has a mean annual rainfall and humidity of 712 mm and 57.1%, respectively ([Birhanu and Berisa, 2015](#)). The mean annual maximum and minimum temperatures of the town are 27.49°C and 12.3°C, respectively. The total human population of the town is estimated at 154,183 with a growth rate of 2.61% ([CSA, 2013](#)).

Sampling: Sampling producers: Babile district, the site of milk production, was stratified into pastoral and agro-pastoral production systems. Each production system was further stratified into peasant associations (PA). Thus, a total of ten PA (5 from pastoral and 5 from agro-pastoral systems) with high cow milk production potential was purposively selected for the study. The PA was further stratified into small (1-3 cows) and medium (4-10 cows) size farms based on the number of milking cows they possess as suggested by [Dayanandan \(2011\)](#). Large size farms (>10 cows) were not considered for this study because of unavailability of farms having more than 10 milking cows. Eventually, milk producer households were selected from each farm size group randomly. The total number of producers was 160 (2 production system * 5 PA * 2 farm size group * 8 households). Thus, the sampling technique employed was multistage stratified sampling.

Sampling milk collectors and transporters, vendor and consumers: The sampling technique employed for identification of milk collectors and transporters, vendors and consumers was snowball sampling technique.

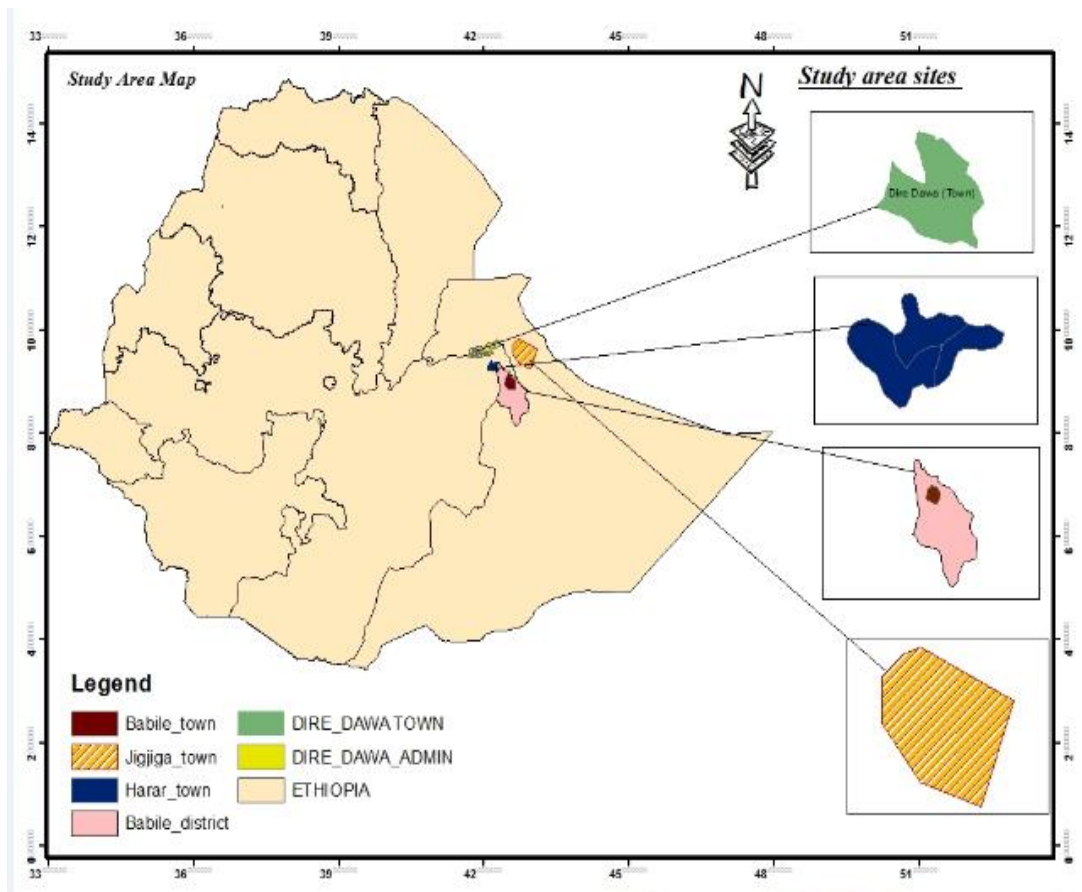


Figure1. The locations of the study areas in eastern Ethiopia

Accordingly, 54 milk collectors and transporters (5 from Jigjiga, 40 from Harar and 9 from Dire Dawa town), 152 vendors (40 from Bable, Harar and Dire Dawa town and 32 from Jigjiga town) and 160 consumers (40 from each town) were selected for the study.

Data collection procedures: The data were collected using focus group discussion and questionnaire survey. Focus group discussion was held with selected producers to generate information on the hygienic milk handling practices in the study area. This was followed by questionnaire survey, which was pre-tested before administration. The questionnaire survey was conducted with milk producers, collectors and transporters, vendors and consumers at respective towns to gather information on hygienic milk handling practices. Secondary data was also collected from different government and non-government offices to augment the questionnaire survey. Moreover, the current milk handling practices of actors was also checked by the researcher.

Statistical analysis: Data collected from the study using structured questionnaires as well as from observation was analyzed with Statistical Package for Social Science

(SPSS) version 16.0 (SPSS, 2007). Descriptive statistics was used to quantitatively express the responses of the study participants with respect to their demographic characteristics as well as the factors responsible for raw cow's milk contamination with spoilage and pathogenic microorganisms in the study area.

RESULTS AND DISCUSSION

Socio-economic and Demographic Characteristics of Actors

The socio-economic and demographic characteristics of milk producers, collectors and transporters, vendors and consumers in the study area are presented in **Table 1**. The data indicated that milk handling, transporting and vending were entirely undertaken by females. For example, in pastoral and agro-pastoral production system, the proportion of females involved in milk handling ranges from 92.5-97.5% and 95-97.5%, respectively. Almost all collectors and transporter, and vendors who were involved in milk collection, transportation and vending were also females. Moreover, majority (85, 87.5, 72.5 and 97.5% at Jigjiga, Babile, Harar

Table 1. Demographic characteristics of actors in the study area

| Variable | Milk producers | | | | Informal milk collectors and transporters | | | Informal milk vendors | | | | Milk consumers | | | |
|-------------------------------|----------------|---------------|---------------|---------------|---|--------|-----------|-----------------------|--------|--------|-----------|----------------|--------|--------|-----------|
| | PPS | | APPS | | Jigjiga | Harar | Dire Dawa | Jigjiga | Babile | Harar | Dire Dawa | Jigjiga | Babile | Harar | Dire Dawa |
| | MSF (n=40) | SSF (n=40) | MSF (n=40) | SSF (n=40) | (n=5) | (n=40) | (n=9) | (n=32) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) |
| Gender (%) | | | | | | | | | | | | | | | |
| Male | 7.5 | 2.5 | 5.0 | 2.5 | 0.0 | 0.0 | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 | 12.5 | 27.5 | 2.5 |
| Female | 92.5 | 97.5 | 95.0 | 97.5 | 100.0 | 100 | 33.3 | 100 | 100 | 100 | 100 | 85.0 | 87.5 | 72.5 | 97.5 |
| <i>Age (in year) (%)</i> | | | | | | | | | | | | | | | |
| 11-20 | 5.0 | 2.5 | 0.0 | 5.0 | 0.0 | 7.5 | 0.0 | 0.0 | 2.5 | 2.5 | 0.0 | 5.0 | 5.0 | 7.5 | 2.5 |
| 21-30 | 20.0 | 40.0 | 22.5 | 25.0 | 20.0 | 10.0 | 22.2 | 12.5 | 17.5 | 30.0 | 5.0 | 25.0 | 40.0 | 25.0 | 22.5 |
| 31-40 | 65.0 | 55.0 | 62.5 | 55.0 | 40.0 | 37.5 | 44.5 | 28.1 | 37.5 | 45.0 | 25.0 | 40.0 | 42.5 | 52.5 | 40.0 |
| 41-50 | 10.0 | 2.5 | 12.5 | 15.0 | 40.0 | 32.5 | 33.3 | 53.1 | 32.5 | 22.5 | 55.0 | 27.5 | 10.0 | 15.0 | 30.0 |
| >50 | 0.0 | 0.0 | 2.5 | 0.0 | 0.0 | 12.5 | 0.0 | 6.25 | 10.0 | 0.0 | 15.0 | 2.5 | 2.5 | 0.0 | 5.0 |
| <i>Religion (%)</i> | | | | | | | | | | | | | | | |
| Muslim | 100 | 100 | 100.0 | 100.0 | 100 | 100 | 100 | 100.0 | 100 | 92.5 | 97.5 | 95.0 | 77.5 | 90.0 | 95.0 |
| Christian | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.5 | 2.5 | 5.0 | 22.5 | 10.0 | 5.0 |
| Level of education (%) | | | | | | | | | | | | | | | |
| Illiterate | 92.5 | 90.0 | 92.5 | 87.5 | 100.0 | 90.0 | 88.9 | 90.7 | 85.0 | 77.5 | 87.5 | 47.5 | 37.5 | 37.5 | 40.0 |
| Basic | 7.5 | 10.0 | 7.5 | 12.5 | 0.0 | 7.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Primary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 0.0 | 6.2 | 12.5 | 17.5 | 7.5 | 27.5 | 15.0 | 37.5 | 17.5 |
| Secondary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.1 | 3.1 | 2.5 | 5.0 | 5.0 | 20.0 | 35.0 | 25.0 | 37.5 |
| >secondary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 12.5 | 0.0 | 5.0 |
| Training (%) | | | | | | | | | | | | | | | |
| Yes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| No | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 | 100.0 | 100.0 | 100.0 | 100 | 100.0 |

PPS= Pastoral Production System; APPS= Agro-pastoral production system; SSF=small size farm; MSF=Medium size farm

Table 2. Personal hygiene of actors across the milk supply chain in the study area (%)

| Variable | Milk producers | | | | Informal milk collectors and transporters | | | Informal milk vendors | | | | Milk consumers | | | |
|---|----------------|--------|--------|--------|---|--------|-------|-----------------------|--------|--------|--------|----------------|--------|--------|--------|
| | PPS | | APPS | | Jigjiga | Harar | DD | Jigjiga | Babile | Harar | DD | Jigjiga | Babile | Harar | DD |
| | MSF | SSF | MSF | SSF | | | | | | | | | | | |
| | (n=40) | (n=40) | (n=40) | (n=40) | (n=5) | (n=40) | (n=9) | (n=32) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) |
| Always stop milk handling while showing disease symptoms | | | | | | | | | | | | | | | |
| No | 90.0 | 87.5 | 92.5 | 90.0 | 80.0 | 85.0 | 77.8 | 90.6 | 77.5 | 75.0 | 85.0 | 77.5 | 82.5 | 72.5 | 80.0 |
| Yes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.5 | 5.0 | 10.0 | 7.5 |
| Sometimes | 10.0 | 12.5 | 7.5 | 10.0 | 20.0 | 15.0 | 22.2 | 9.4 | 22.5 | 25.0 | 15.0 | 15.0 | 12.5 | 17.5 | 12.5 |
| Wash hands before start milk handling | | | | | | | | | | | | | | | |
| Yes | 52.5 | 65.0 | 72.5 | 80.0 | 0.0 | 7.5 | 0.0 | 81.2 | 85.0 | 92.5 | 62.5 | 90.0 | 97.5 | 85.0 | 95.0 |
| No | 47.5 | 35.0 | 22.5 | 20.0 | 100.0 | 92.5 | 100.0 | 18.8 | 15.0 | 7.5 | 37.5 | 10.0 | 2.5 | 15.0 | 5.0 |
| Methods of washing hands | | | | | | | | | | | | | | | |
| Cold water only | 52.5 | 65.0 | 72.5 | 80.0 | 0.0 | 7.5 | 0.0 | 81.2 | 85.0 | 92.5 | 62.5 | 90.0 | 97.5 | 85.0 | 95.0 |
| Exposure to risk factors while working with milk | | | | | | | | | | | | | | | |
| Exposed | 92.5 | 87.5 | 90.0 | 85.0 | 80.0 | 90.0 | 77.8 | 100.0 | 100.0 | 95.0 | 97.5 | 55.0 | 62.5 | 57.5 | 67.5 |
| Not exposed | 7.5 | 12.5 | 10.0 | 15.0 | 20.0 | 10.0 | 22.2 | 0.0 | 0.0 | 5.0 | 2.5 | 45.0 | 37.5 | 42.5 | 32.5 |
| Method of removing physical hazards from the milk when available | | | | | | | | | | | | | | | |
| Bare hand | 80.0 | 77.5 | 72.5 | 65.0 | 60.0 | 67.5 | 88.9 | 78.1 | 57.5 | 75.0 | 87.5 | 35.0 | 32.5 | 27.5 | 42.5 |
| Stick | 15.0 | 17.5 | 20.0 | 15.0 | 40.0 | 32.5 | 11.1 | 3.1 | 22.5 | 15.0 | 10.0 | 5.0 | 0.0 | 0.0 | 2.5 |
| Spoon | 5.0 | 5.0 | 7.5 | 20.0 | 0.0 | 0.0 | 0.0 | 18.8 | 20.0 | 10.0 | 2.5 | 60.0 | 67.5 | 72.5 | 55.0 |
| Protect milk from being exposed to coughing & sneezing | | | | | | | | | | | | | | | |
| Yes | 45.0 | 47.5 | 45.0 | 50.0 | 40.0 | 47.5 | 44.4 | 43.8 | 37.5 | 47.5 | 40.0 | 57.5 | 60.0 | 62.5 | 55.0 |
| No | 55.0 | 52.5 | 55.0 | 50.0 | 60.0 | 52.5 | 55.6 | 56.2 | 62.5 | 52.5 | 60.0 | 42.5 | 40.0 | 37.5 | 45.0 |

PPS=pastoral production system; APPS=agro-pastoral production system; MSF=Medium size farm; SSF=small size farm; DD=Dire Dawa

Table 3. Equipments used for milk handling and sanitary practices performed by milk producers and collectors and transporters (%)

| Variable | Producers | | | | Informal milk collectors | | |
|---|---------------|---------------|---------------|---------------|--------------------------|--------|-------|
| | PPS | | APPS | | Jigjiga | Harar | DD |
| | MSF (n=40) | SSF (n=40) | MSF (n=40) | SSF (n=40) | (n=5) | (n=40) | (n=9) |
| Type of equipment used | | | | | | | |
| Plastic containers | 97.5 | 95.0 | 87.5 | 90.0 | 100 | 100 | 100 |
| Aluminum cans | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Traditional containers | 2.5 | 5.0 | 12.5 | 10.0 | 0.0 | 0.0 | 0.0 |
| Frequency of cleaning | | | | | | | |
| Once | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Twice | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Method of cleaning | | | | | | | |
| Cold water with detergent | 17.5 | 12.5 | 7.5 | 10.0 | 0.0 | 2.5 | 0.0 |
| warm water with detergent | 82.5 | 87.5 | 92.5 | 90.0 | 100.0 | 97.5 | 100 |
| Physical scrubbing with | | | | | | | |
| Sand | 97.5 | 95.0 | 87.5 | 90.0 | 100 | 100 | 100 |
| Sponge or clothes | 2.5 | 5.0 | 12.5 | 10.0 | 0.0 | 0.0 | 0.0 |
| Smoke milk equipments | | | | | | | |
| Yes | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| No | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Commonly used material for smoking | | | | | | | |
| Ejersa* (<i>Olea africana</i>) ^a | 42.5 | 45.0 | 42.5 | 40.0 | 40.0 | 40.0 | 33.33 |
| Mi'eessaa* (<i>Euclea schimperii</i>) ^a | 15.0 | 10.0 | 20.0 | 22.5 | 0.0 | 20.0 | 22.22 |
| Bir'eensa* (<i>Terminalia brownii</i>) ^a | 30.0 | 35.0 | 20.0 | 27.5 | 40.0 | 30.0 | 33.33 |
| Jimaa* (<i>Catha edulis</i>) ^a | 12.5 | 10.0 | 17.5 | 10.0 | 20.0 | 10.0 | 11.11 |
| Proper protection of milk containers FCWRFACS | | | | | | | |
| Yes | 7.5 | 10.0 | 7.5 | 12.5 | 0.0 | 32.5 | 11.11 |
| No | 92.5 | 90.0 | 92.5 | 87.5 | 100 | 67.5 | 88.89 |
| Properly protect cups used for milk delivery form risk factors | | | | | | | |
| Yes | 0.0 | 2.5 | 0.0 | 2.5 | 0.0 | 2.5 | 0.0 |
| No | 100 | 97.5 | 100 | 97.5 | 100 | 97.5 | 100 |

FCWRFACS=from contact with risk factors after cleaning and smoking; SSF=small size farm; MSF=medium size farm; PPS=pastoral production system; APPS=agro-pastoral production system; DD=Dire Dawa; *local name; ^aScientific name

and Dire Dawa town, respectively) of consumers who prepared milk for home consumption were females. The finding agrees with [Demissie et al. \(2015\)](#) who reported that about 94.2% of milk handling and marketing in Gursum district of Oromia Region, Ethiopia was undertaken by women.

The majority of respondent milk producers in pastoral (90-92.5%) and agro-pastoral (87.5-92.5%) production system were illiterate. The finding agrees with [Kuma et al. \(2013\)](#) who reported that majority (58.3%) of milk producers in Borana pastoral community were illiterate. Moreover, majority of milk collectors and transporters (88.9-100%), vendors (77.5-90.7%) and consumers (37.5-47.5%) in this study were illiterate. This was consistent with [Mattias \(2013\)](#) who reported that majority of small-

scale agents (collectors and transporter as well as vendors) in Kiambu County in Kenya were illiterate. Furthermore, none of respondent milk handler across the milk supply chain in the study area did get formal training on hygienic milk handling practices. It is believed that the ability to read and write would enable milk handlers to better understand proper hygienic measures which need to be exercised during milk handling to protect milk from spoilage and pathogenic microbial contamination ([Wayua et al., 2012](#); [Kuma et al., 2013](#)). Similarly, formal training is critically important to protect the milk from microbial contamination while handling; because it increases the skill of milk handlers on hygienic milk handling practices ([Kuma et al., 2015](#)). The high proportion of illiteracy as well as absence of any formal training on hygienic milk handling practices in the current findings might have

Table 4. Equipments used for milk handling and sanitary practices performed by milk vendors and consumers (%).

| Variable | Informal milk vendors | | | | Milk consumers | | | |
|---|-----------------------|--------|-------|------|----------------|--------|-------|------|
| | Jigjiga | Babile | Harar | DD | Jigjiga | Babile | Harar | DD |
| | n=32 | n=40 | n=40 | n=40 | n=40 | n=40 | n=40 | n=40 |
| Type of equipment used | | | | | | | | |
| Plastic containers | 100 | 100 | 100 | 100 | 32.5 | 17.5 | 12.5 | 22.5 |
| Aluminum cans | 0.0 | 0.0 | 0.0 | 0.0 | 40.0 | 65.0 | 37.5 | 65.0 |
| Plastic Bags | 0.0 | 0.0 | 0.0 | 0.0 | 27.5 | 17.5 | 50.0 | 12.5 |
| Frequency of cleaning | | | | | | | | |
| Once | 100 | 100 | 100 | 100 | 87.5 | 75.0 | 67.5 | 75.0 |
| Twice | 0.0 | 0.0 | 0.0 | 0.0 | 12.5 | 25.0 | 32.5 | 25.0 |
| Method of cleaning | | | | | | | | |
| Cold water with detergent | 15.4 | 0.0 | 0.0 | 70.0 | 55.0 | 72.5 | 82.5 | 77.5 |
| Warm water with detergent | 84.6 | 100 | 100 | 30.0 | 45.0 | 27.5 | 17.5 | 22.5 |
| Physical scrubbing with | | | | | | | | |
| Sand | 96.9 | 72.5 | 52.5 | 97.5 | 0.0 | 0.0 | 0.0 | 2.5 |
| Sponge or clothes | 3.1 | 17.5 | 25.0 | 2.5 | 62.5 | 52.5 | 72.5 | 87.5 |
| Brush having good bristles | 0.0 | 10.0 | 22.5 | 0.0 | 37.5 | 47.5 | 27.5 | 10.0 |
| Smoke milk equipments | | | | | | | | |
| Yes | 100 | 100 | 100 | 100 | 5.0 | 15.0 | 0.0 | 2.5 |
| No | 0.0 | 0.0 | 0.0 | 0.0 | 95.0 | 85.0 | 100 | 97.5 |
| Commonly used material for smoking | | | | | | | | |
| Ejersa*(<i>Olea africana</i>) ^a | 59.37 | 67.5 | 42.5 | 60.0 | 5.0 | 7.5 | 0.0 | 2.5 |
| Bir'eensa*(<i>Terminalia brownii</i>) ^a | 15.63 | 12.5 | 27.5 | 20 | 0.0 | 2.5 | 0.0 | 0.0 |
| Jimaa*(<i>Catha edulis</i>) ^a | 25.0 | 20.0 | 30.0 | 20 | 0.0 | 5.0 | 0.0 | 0.0 |
| Proper protection of milk containers FCWRFACS | | | | | | | | |
| Yes | 6.2 | 2.5 | 0.0 | 0.0 | 22.5 | 32.5 | 42.5 | 27.5 |
| No | 93.8 | 97.5 | 100 | 100 | 77.5 | 67.5 | 57.5 | 72.5 |
| Properly protect cups used for milk delivery form risk factors | | | | | | | | |
| Yes | 0.0 | 0.0 | 5.0 | 2.5 | 30.0 | 27.5 | 45.0 | 30.0 |
| No | 100 | 100 | 95.0 | 97.5 | 70.0 | 72.5 | 55.0 | 70.0 |

FCWRFACS=from contact with risk factors after cleaning and smoking; *Local name; ^aScientific name; DD=Dire Dawa;

negative effect on clean, wholesome and nutritious milk production to consumers.

Personal hygiene of milk handlers across the milk supply chain is presented in **Table 2**. The study showed that majority of respondent milk producers, collectors and transporters, vendors and consumers in the study area did not stop milk handling while showing disease symptoms such as diarrhea, infected cuts/lesions on hands, persistent coughing and sneezing. According to [Musa and Akande \(2003\)](#), the person showing disease symptoms should not participate on milk handling operation. This is because sick person may shed huge amount of pathogenic organisms during sneezing, coughing, scratching, vomiting, urination and defaecation, and become a potential source for contamination of milk and milk utensils with pathogenic microorganisms.

On the other hand, majority of the observed milk producers (52.5-80%), vendors (62.5-92.5%) and consumers (85-97.5%) in the study area wash their hands before milk handling. Similarly, most (92.5%) of the

observed milk collectors and transporters who transport raw milk to Harar town wash their hands before milk handling; however, none of the ones who transport to Jigjiga and Dire Dawa towns did wash their hands before milk handling.

Among milk producers, collectors and transporters, vendors and consumers who wash their hands before milk and milk equipments handling, none of them use warm water and detergent for hand washing rather cold water without detergent. Washing hands with cold water without detergent lead to insufficient cleaning to remove germs and serves as a major source of microbial contamination of milk ([Efsun et al., 2008](#)). Moreover, all of the actors starting from milk producers to consumers use wet hand while working with milk. During the process, it is possible that water droplets may enter the milk and add spoilage and pathogenic bacteria from insufficiently cleaned hands and affect the quality and safety of food including milk ([Omemu and Aderoju, 2008](#)). Therefore, milk handlers should always wash their hand with warm water and detergent, and then dry it

properly with paper towels before starting milk handling or preparation ([Zelalem, 2012](#); [Al Suwaidi et al., 2015](#)).

Majority of the observed milk producers (85-92.5%), collectors and transporters (77.8-80%) vendors (95-100%) and consumers (55- 67.5%) in the study area were exposed to a variety of risk factors while preparing milk for marketing and consumption. Moreover, none of the observed milk producers, collector and transporter, vendor and consumer was washing their hands after every milk handling and exposure to risk factors. This could be attributed to lack of awareness and become possible source of contamination for both spoilage and pathogenic microbes. Exposure to risk factors (such as handling paper money or coins as well as soiled equipments or any part of the body) while working with milk may increase the risk of contamination of milk with pathogenic microbes especially *Staphylococcus aureus*, and contribute to the occurrence of food-borne disease outbreaks ([Mahami et al., 2013](#); [Gamal et al., 2015](#)). It is, therefore, important that food handlers should avoid handling soiled equipments and others risk factors for hygienic milk production.

The majority of observed milk producers (52.5-55%), collectors and transporters (52.5-60%) vendors (52.5-62.5%) and some consumers (37.5-42.5%) at the respective study sites were not taking precautions to avoid coughing or sneezing over milk while working with milk, which were perhaps attributed to lack of awareness. According to [Laura et al. \(2006\)](#) habits like coughing or sneezing over food including milk while handling, increase the risk of contamination of food (like milk) with microorganisms. Moreover, none of observed milk producers, collectors and transporter, vendors and consumers in the study area dressed clean outer garment while working with milk. This may increase the risk of contamination of milk with spoilage and pathogenic microorganism. According to [Zelalem \(2012\)](#) and [Meleko et al. \(2015\)](#), absence of wearing clean outer garment while working with food including milk enhances the contamination of food (like milk) with both spoilage and pathogenic microorganisms.

Majority of observed milk producers (65-80%), collectors and transporter (60-88.9%), vendors (57.5- 87.5%) and some consumers (27.5-42.5%) in the study sites use their bare hand to remove physical hazards such as cow dung and hair from the milk. This practice undoubtedly results in cross contamination of milk with spoilage and pathogenic microbes that come from contaminated hands and leads to occurrence of food-borne disease outbreaks as well as spoilage of food including milk before it reach to its final destination. Various reports indicate that

malpractices such as handling or touching food including milk with unclean bare hands may contribute to the occurrence of food-borne disease outbreaks ([Laura et al., 2007](#); [Omemu and Aderoju, 2008](#)).

Milk handling equipments and sanitary practices

The equipments used for milk handling and the sanitary practices related to milk handling equipments across the supply chain are presented in **Table 3 and 4**. The results of this study revealed that the majority of milk producers (87.5-97.5%) and all milk collectors and transporters as well as vendors in the study area were using plastic containers for raw milk handling. Similarly, some consumers (about 32.5, 17.5, 12.5 and 22.5% of consumers at Jigjiga, Babile, Harar and Dire Dawa town, respectively), were using plastic containers. This finding agrees with that of [Mattias \(2013\)](#), who reported that the majority of milk producers and almost all small-scale agents (collectors and transporters as well as vendors) used plastic jerry cans for milk handling in Kiambu County in Kenya. The use of plastic containers is not advisable as it is sensitive to heat. Moreover, its surface is easily scratched by nature with the common cleaning systems. As a result, after some time the surface will contain a number of scratches, which can hardly be seen but are nearly impossible to clean with the common cleaning systems and provide hiding places for bacteria during cleaning and sanitization. This allows the multiplication of bacteria on milk contact surfaces during the intervals between milk handlings and becomes a potential source for contamination of milk with spoilage and pathogenic microorganisms ([Pandey and Voskuil, 2011](#)).

In contrast, the majority of consumers in all towns except in Harar indicated that they were using aluminum cans; whereas, some consumers at Jigjiga (27.5%), Babile (17.5%), and Dire Dawa (12.5%), and the majority of consumers at Harar (50%) indicated that they were using plastic bags. In connection with this, some researchers had reported that aluminum or stainless steel is preferred to other containers for milk handling ([Zelalem, 2012](#); [Bereda et al., 2012](#)). It is, therefore, important for milk handlers to pay particular attention to the type of milk equipment used to ensure the quality and safety of milk produced and marketed in the area.

With respect to cleaning methods practiced in the area, the results indicated that the majority of milk producers (82.5-90%), collectors and transporters (97.5-100%), vendors (30-100%) and some consumers (17.5-45%) wash their milk handling equipment with warm water and detergent (like Ajax and leaves *Lantana camara*); whereas,

only few of milk producers (12.5-17.5%), collectors and transporters (0-2.5%), some vendors (0-70%) and the majority of consumers (55-82.5%) wash the milk handling equipment with cold water and detergent. The finding agrees with [Lumadede et al. \(2010\)](#) who reported that almost all pastoral and agro-pastoral milk producers and the majority (78%) of the traders wash their milk handling equipments with warm water and detergent. However, it contradict with the finding of [Worku et al. \(2014\)](#) who reported majority (69.7%) of respondents wash their milk handling equipments with cold water and detergent.

Manual cleaning requires physical scrubbing action in order to remove the food debris that the detergent has loosened. This study indicated that the majority of respondents and observed milk producers (90-97.55), vendors (52.5-96.9%) and all collectors and transporters in the study area use sands for scrubbing of the internal surface of plastic jerry cans used for raw milk handling. This causes scratching of the internal surface of plastic jerry cans and increases the chance for bacteria to attach to the surface and form a biofilm, which could then contaminate milk over time with spoilage and other harmful bacteria. Moreover, sands may likely contain both bacteria and spores, which may contaminate the jerry can instead of cleaning it ([Mattias, 2013](#)) and expose milk for microbial contamination. Unlike the milk producers, collectors & transporters and vendors, the majority of milk consumers at Jigjiga (62.5%), Babile (52.5%), Harar (72.5%) and Dire Dawa (87.5%) town were using sponges or clothes to clean their milk handling equipments. The use of sponge or clothes for scrubbing of food containers including milk handling equipments is not recommendable as they are inefficient for proper scrubbing of milk contact surfaces and often spread germs and become a major source for milk contamination with microorganisms ([Hilton and Austin, 2000](#); [Haysom and Sharp, 2005](#); [Carol et al., 2013](#)).

Washing of milk handling equipments across the supply chain takes place once a day followed by drying (for 5-10minutes) and fumigation with smoke from burning stems of specific plant species such as Ejersa (*Olea africana*), Bir'eensa (*Terminalia brownie*), Mi'eessaa (*Euclea schemper*) and Jimaa (*Catha edulis*). After cleaning and smoking, the majority of the observed milk producers (87.5-92.5%), collectors and transporters (67.5-100%), vendors (93.8- 100%) and consumers (57.5-77.5%) were not properly protecting their milk handling equipments from flies, dusts and other dirt. This might have served as a possible source of contamination of milk by both spoilage and pathogenic microorganisms.

Delivery of raw and boiled milk to the next actors especially at the milk collection and vending sites is commonly done using cups. The majority of the observed milk producers (97.5-100%), collectors and transporters (97.5-100%) and vendors (95-100%) in the study area use these cups throughout the selling period neither cleaning properly at every selling nor providing proper protection from flies, dusts, and other contaminant agents. Similarly, the majority of consumers at Jigjiga (70%), Babile (72.5%), Harar (55%) and Dire Dawa (70%) were not properly protecting milk-drinking cups from flies, dusts and other dirt after use and cleaning. This may be due to lack of knowledge or awareness, and these cups become a likely source for contamination of milk with microorganisms.

Source of water

The source of water used for hygienic practices across the milk supply chain is presented in **Table 5**. The data show that the majority of the respondents milk producers in pastoral (57.5-62.5%) and agro-pastoral (42.5-45%) production system use water from sources other than the tap (such as wells, spring, river, stream and water collected from flood), followed by tap water. The finding agrees with the finding of [Bereda et al. \(2013\)](#) who reported majority (64.4%) of respondent milk producers in Ezha district, Ethiopia were using water from non-tap sources for hygienic practices. Moreover, the majority of milk collectors and transporters who transport raw milk to Jigjiga (60%), Harar (60%) and Dire Dawa (66.7%) use water from non-tap sources. Such practices could contribute to poor bacteriological quality of milk ([Jayarao et al., 2004](#)). Water used for hygienic practices should be of potable quality ([Hofi, 2011](#); [Zelalem, 2012](#)).

If it is impossible to obtain water of potable quality, water obtained from river, stream, spring and hand dug well should be treated prior to use ([Zelalem, 2012](#); [Bereda et al., 2012](#)). However, among the respondents that reported to used water from non-tap sources, none was treating his/her washing water prior to use for hygienic practices. Moreover, the majority of respondents milk vendors (80-100%) and consumers (72.5- 92.5%) in the study sites were not treating their washing water prior to use. This practice undoubtedly increases the risk of milk contamination with spoilage and pathogenic microorganisms. It is, therefore, important to heat or chemically treat water from non-tap sources prior to use for hygienic practice.

Table 5: Source of water used for hygienic practices across the supply chain (%)

| Variable | Milk Producers | | | | Informal milk collectors and transporters | | | Informal milk vendors | | | | Milk consumers | | | |
|---|----------------|---------------|---------------|---------------|---|--------|-----------|-----------------------|--------|--------|-----------|----------------|--------|--------|-----------|
| | PPS | | APPS | | Jigjiga | Harar | Dire Dawa | Jigjiga | Babile | Harar | Dire Dawa | Jigjiga | Babile | Harar | Dire Dawa |
| | MSF (n=40) | SSF (n=40) | MSF (n=40) | SSF (n=40) | (n=5) | (n=40) | (n=9) | (n=32) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) | (n=40) |
| Source of water | | | | | | | | | | | | | | | |
| *Open water supply | 62.5 | 57.5 | 42.5 | 45.0 | 60.0 | 60.0 | 66.7 | 50.0 | 10.0 | 7.5 | 0.0 | 55.0 | 0.0 | 2.5 | 0.0 |
| Hand pipe | 37.5 | 42.5 | 57.5 | 55.0 | 20.0 | 40.0 | 33.3 | 0.0 | 37.5 | 12.5 | 0.0 | 0.0 | 25.0 | 22.5 | 0.0 |
| City Pipeline | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 0.0 | 50.0 | 52.5 | 80.0 | 100 | 45.0 | 75.0 | 75.0 | 100 |
| Always treat water before use for hygienic practices | | | | | | | | | | | | | | | |
| Yes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| No | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 81.25 | 80.0 | 92.5 | 100 | 72.5 | 85.0 | 90.0 | 92.5 |
| Sometimes | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.75 | 20.0 | 7.5 | 0.0 | 27.5 | 15.0 | 10.0 | 7.5 |
| Method of treatment | | | | | | | | | | | | | | | |
| Chemical | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.75 | 20.0 | 7.5 | 0.0 | 27.5 | 15.0 | 10.0 | 7.5 |
| Physical (Boiling) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Others | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

PPS= Pastoral production system; APPS= Agro-pastoral production system; SSF=small size farm; MSF=medium size farm; *Open water supply includes wells, spring, river, stream and water collected from flood

Method of raw milk transportation across the milk supply chain

Almost all milk producers in both production systems transport their milk to nearby roadside milk collection center by donkey or women on their backs. After receiving raw milk from producers, collectors and transporters prepare (change and code containers) the milk for transport. Then after, raw milk from sites of collection to Harar, Dire-Dawa, and Jigjiga town (31, 86, and 74 km, respectively, from milk production site) was transported by car. After receiving raw milk from collectors and transporters, vendors at selected towns transport their milk from site of purchase to site of vending by cars, cart horses, three wheelers and women on their backs. The use of such transportation systems (donkey and women's back, cars, cart horses and three wheelers) are not suitable especially when important hygiene and food-safety considerations are taken into account as they do not provide facilities for refrigeration ([Wayua et al., 2012](#)). Moreover, raw milk was transported along with passengers, goats, tomatoes, mangoes and other market goods which are public health concerns.

Hygiene of milk marketing place across the milk supply chain

The results of this study indicated that all of the observed milk producers, collectors and transporters in the study areas carried out raw milk delivery to the next actors in the open sunshine and at roadsides on the ground, which were dusty and not protected from wind and road traffic. This may be a possible source for microbial contamination of raw milk in the market chain, as the milk was typically exposed to high temperature, road traffic, wind and dusty conditions for prolonged periods of time during the process of milk collection, changing containers and coding.

Similarly, none of the observed milk vendors in the selected towns has milk preparation and selling areas which are well protected from sun, dust, wind, road traffic, garbage and waste. This observation is similar to the finding of [Muyanga et al. \(2011\)](#) who reported that the majority of food vendors in Niger were preparing and selling their food in areas which were not well protected from different contaminant agents (like sun, dust, wind, road traffic, garbage and others). According to [Ackah et al. \(2011\)](#), food catering places including milk preparation and selling areas should be sheltered (protected) from sun, dust, wind, road traffic, garbage and waste, as such areas undoubtedly expose food (like milk) for microbiological contamination.

Whenever it is totally difficult to keep clean or protect food preparation and selling areas from contaminant agents (like dust, wind, road traffic, flies and other contaminant agents), the displayed food including milk as well as its handling equipments should properly be covered or protected from contamination ([Gerald, 2001](#)). However, the majority of observed milk producers, collectors and transporters, and vendors were not properly covering or protecting their milk handling equipments (especially cups used for selling and drinking) from contamination (**Table 3** and **4**) and as a result many flies and a mass of dust were usually seen covering the milk handling containers. Dusts and flies carry many spoilage and pathogenic microorganisms and may, therefore, contaminate the milk if left to settle on street foods as well as the handling equipments ([Ackah et al., 2011](#)). This might result in significant loss of the quality of milk as well as might result in food-borne disease outbreak.

CONCLUSION

In the studied milk supply chain, the majority of milk producers, collectors and transporters, vendors and some consumers who were involved in milk handling were females and illiterate without any training on hygienic milk handling practices. Malpractices such as failure to stop milk handling while showing disease symptoms and/or signs, improper hand washing, failure to wash hands between each milk handling, handling of risk factors while working with milk were common. The most widely used milk vessels in the study area by majority of milk producers, all traders and some consumers were plastic containers; and the most common washing practice performed by most actors except consumers was the use of warm water, detergent and sand. In most cases, equipments were not protected from risk factors (like flies, dusts, etc) after cleaning and smoking. Majority of milk handlers in the study area use water from sources other than tap and none of them were practicing to treat non-tap water prior to use for hygienic practices. Moreover, milk was transported to market places using poor means of transportation including on the backs of donkeys and women, and small vehicles that were not equipped with refrigerators. Furthermore, in almost all cases delivery of raw milk to the next actors was carried out in the open sunshine and at roadsides on the ground, which were dusty and not protected from wind, road traffic, garbage and waste. In general, the milk handling activities performed across the milk supply chain in the study area were unhygienic which may be mainly due to lack of knowledge on hygienic practices, and undoubtedly affect quality and safety of milk produced and marketed

in the supply chain. Therefore, the concerned governmental and non-governmental institutions should pay attention to the improvement of hygienic practices through undertaking relevant development interventions across the supply chain.

CONFLICT OF INTEREST

The authors declare that they have no competing interest.

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