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Hygienic Milk Production Practices in Pastoral and Agro-Pastoral Production Systems in Babile District, Eastern Ethiopia

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ABSTRACT

This study was conducted to investigate hygienic cow milk production practices in Babile district of eastern Ethiopia. A total of 160 milk producers were selected from pastoral and agro-pastoral production systems using stratified random sampling technique. Data were collected using questionnaire survey and field observation. The majority of respondents in pastoral (92.5%-95%) and agro-pastoral (87.5-90%) production systems were illiterate where none of them had gotten training on hygienic milk production practices. Most of the respondents in both production systems were not discarding milk from diseased cows and teats but used for home consumption and market, however, the proportion (43.8%) of agro-pastoralists who discard milk from diseased cows/teats were significantly (P = 0.03) higher than that for pastoralist (22.5%).The use of milk from cows on medication before drug withdrawal periods was common in the majority of respondents in pastoral (82.5%) and agro-pastoral (62.5%) production systems. All of the respondents in the study area keep their cattle in separate corrals which are poor in their drainage system and difficult to clean, and are uncomfortable to animals. The majority (75%) of the respondents in the study area reported that they used to milk cows while the cows showing disease symptoms. About 50% from pastoral and 65% from agro-pastoral areas reported that they used to wash hands with cold water before milking. Plastic equipment was the commonly used milking utensil in the study area. The milking utensils were commonly washed with cold water with Ajax soap/leaves of Lantana camara as detergent. Calf suckling was commonly used as a method of cleaning teats before milking by large proportion of respondents in pastoral (92.5%) and agro-pastoral (86.3%) production systems. The majority of the respondents in pastoral (60%) and some from agro-pastoral (43.8%) production systems were using water from non-tap sources for hygienic practices. Moreover, none of the respondents in the district treat wash-water prior to use for hygienic practices. In general, milk production practices performed in the study area were unhygienic. It is, therefore, suggested the need for improving hygienic practices through awareness creation and capacity development of milk producers on hygienic practices essential for safe milk production in the district. Moreover, providing better quality water for producers is very crucial

Key Words: Agro-pastoral production system, hygienic, herd size, pastoral production system,

1. Introduction

Milk is the lacteal secretion of the mammary glands of mammal. It is a complex biological fluid containing different components like water, lipids, proteins (casein and whey), carbohydrates (mainly lactose), amino acids, vitamins and minerals (mainly calcium) essential for growth (Javaid et al., 2009). It is the most perfect single balanced food of high biological value in nature as it contains almost all ingredients of food in right proportion and in any easily digestible form and has highly been recognized as complete food, and is recommended as compulsory part of daily diet for the expectant mothers, growing children and immuno-compromised persons (Pandey and Voskuil, 2011).

Although milk from other mammalian farm animal is used as human food, cow milk is the most commonly used human food in the world as it is consumed without any taboo across the different parts of the countries. It plays an important role in feeding of both rural and urban population particularly in developing countries (Ali et al., 2010). This is because it is a potential key source of energy, essential amino acids and micronutrients, particularly needed in less-developed countries, where diets are mainly based on staple grains or root crops (Fitzhugh and Chantalakhana, 1999). Cow milk is also an economically important farm commodity and investment option for smallholder farmers in Ethiopia (Welearegay et al., 2012) and significantly contributing to the household food security (Bereda et al., 2012), as it alleviates poverty and mitigates malnutrition.

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The fluid or semi-fluid nature of cow milk and its chemical composition makes it one of the ideal media for the growth and multiplication of wide ranges of microorganisms (Soomro et al., 2002). It is well known that fresh milk aseptically drawn from clean and healthy cow normally contains a low microbial count (less than 1000 cfu/ml of milk). However, poor hygiene practices (such as poor health herd management practices, housing condition, milking procedure and personal hygiene of milkers) performed during milk production allow the milk to pick many microbes at farm level (Torkar and Teger, 2008). Moreover, the use of poor farm environment, contaminated water for hygienic practices, poorly cleaned and maintained milking equipment will also allow the milk to pick large number of microorganism at farm level (Bramley, 1990; Chambers, 2002).

The presence of large number of microorganism in the milk will cause spoilage of the milk before it reaches to its final destination points (Kivaria et al., 2006), and cause economic loss to smallholder milk producers. Moreover, it will causes food poisoning (food infections or intoxications), which are major causes of illness and death in developing countries (O'Connor, 1995). Thus, the employment of hygienic practices during milk production is the first and the most important steps in providing clean, wholesome and nutritious milk to consumers, and therefore, has to get due attention (Coorevits et al., 2008). However, milk production in developing countries like Ethiopia, where the consumption of raw milk and its derivatives is common, is commonly done without observing the hygienic practices (Zelalem, 2003; Welearegay et al., 2012). Failure to observe hygienic practices during milk production pose a threat to public health as chances of consuming unsafe milk is very high. It also enhances the loss of income of milk producers through aggravating postharvest loss due to spoilage (Kurwijila, 2006).

The availability of documented information on hygienic milk production practices of producers is highly important to protect the risk of milk contamination with spoilage and pathogenic microorganisms at farm level. This is because such information will be important for governmental, non-governmental and other development organizations to undertake relevant development interventions, which make milk producers to have clear understanding on hygienic milk production practices. This understanding may be important to ensure safety and suitability of raw milk for its intended use as well as to improve income of milk producers through minimizing post-harvest loss due to spoilage, which is a major problem of traditional milk producers in the developing countries like Ethiopia (Kurwijila et al., 2006). However, currently, there is no well documented information available on hygienic milk production practices in the study area. Therefore, the objective of the present study was to investigate hygienic cow milk production practices in Babile district, east Hararghe zone, eastern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Babile district, which is located in eastern Oromia National Regional State, Ethiopia. Geographically, the district is located at 9008' N latitude and 42021' E longitude at the distance of about 557 km east of Addis Ababa. The altitude of the district ranges from 950 to 2000 meter above sea level. It has mean annual minimum and maximum temperatures of 18 and 28^{o}C, respectively. The mean annual rainfall and humidity of the district ranges from 700 to 900 mm and 33 to 38%, respectively (CSA (Central Statistical Agency), 2008b). The district has a total area of 3169.06 km^2, 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 systems (CSA (Central Statistical Agency), 2008b).

The estimated livestock population in the district indicated that cattle are the most prominent livestock species (56,355 heads) followed by goat (23,020), sheep (12,216) and camel (9,704) (Development and Agency, 2015). The district produced about 12,000 and 6,745 liters of raw cow's milk during the wet and dry seasons, respectively (Development and Agency, 2015). Of the total cow milk produced daily in the district, about 50% was used for sale (Demissie et al., 2015). The total human population of the district is estimated at 115, 229, out of which about 21.5% live in Babile town (CSA (Central Statistical Agency), 2008a).

2.2. Sampling and Data Collection

2.2.1. Sampling

Babile district was stratified into pastoral and agro-pastoral production systems. Each production system was further stratified into peasant associations (PAs, the lowest administration unit in Ethiopia). Thus, a total of ten PAs (5 from pastoral and 5 from agro-pastoral systems) with high cow milk production potential were purposively selected for the study. Then the lists of milk producer households in each selected PA were obtained from their respective administration and stratified into small (1 to 3 cows) and medium (4 to 10 cows) size herds based on the number of cows they possessed (Dayanandan, 2011). Large size herds (>10 cows) were not considered for this study as they are not available in the study area. Eventually, eight milk producer households were selected from each herd size group randomly. Thus, the total number of milk producer households selected was 160 (2 production systems * 5 PA * 2 herd size group * 8 milk producer households). The sampling technique employed was multistage stratified sampling.

2.2.2. Data Collection Procedures

After stratification and identification of households, exploratory focused group discussions were held with key informants (such as milk producers having good experience on the subject under study, community leaders and

Table 1: Demographic characteristic of milk producer household head in the study area (%)

Variable	Pastoral production system		Agro-pastoral production system	
	MSH n=40	SSH n=40	MSH n=40	SSH n=40
Sex				
Male	62.5	70.0	75.0	62.5
Female	37.5	30.0	25.0	37.5
Age in year				
<21	0.0	0.0	0.0	0.0
21-30	5.0	10.0	7.5	5.0
31-40	17.5	25.0	25.0	25.0
41-50	62.5	52.5	47.5	60.0
>50	15.0	12.5	20.0	10.0
Level of education				
Illiterate	92.5	95.0	90.0	87.5
Basic reading and writing	7.5	5.0	7.5	12.5
Primary	0.0	0.0	2.5	2.5
Secondary & above	0.0	0.0	0.0	0.0

SSH = Small size herd; MSH = Medium size herd

experts) in each production system to generate information on the hygienic milk production practices. The resulting information was then used for the development of survey questionnaire which was pre-tested before administration. After pre-testing, the questionnaire survey was conducted to gather information on hygienic milk production practices. Moreover, field observations were made to collect some data which were not properly described during the questionnaire survey.

2.3. Statistical Analysis

The collected data were analyzed using Statistical Analysis System (SAS) (System, 2008). Descriptive statistics were used to quantitatively express the responses of the study participants with respect to their demographic characteristics as well as factors responsible for raw cow milk contamination during production in the study area. Chi-square test was employed to examine the differences among categorical variables. Differences were considered to be significant at the level $P < 0.05$.

3. Results and Discussion

3.1. Demographic Characteristics of Milk Producers

Majority of the respondents in pastoral (62.5-70.0%) and agro-pastoral (62.5-75.0%) production systems were male headed households (Table 1). This is relatively comparable with the finding of (Melesse et al., 2014) who reported that majority of the respondent milk producers in Ada'a (73.3%) and Lume (80.0%) district, Ethiopia were male headed households.

The present study indicated that majority of the respondent milk producers in pastoral (92.5-95.0%) and agro-pastoral (87.5-90.0%) production systems were illiterate (Table 1). The finding is in agreement with (Worku et al., 2014) who observed illiteracy rate of 58.3% in Borana pastoral community, Ethiopia. Moreover, none of the respondent milk producers in the study area received trainings on hygienic milk production practices. It is believed that the ability to read and write would enable milk producers to better understand proper hygienic measures which need to be exercised during milk production to protect the milk from microbial contamination at farm level (Kuma et al., 2013). Similarly, training on hygienic milk production practices is highly important to protect the milk from microbial contamination at farm level as such training increases the skill of milk producers about hygienic practices essential for safe milk production (Kuma et al., 2015). The high proportion of illiteracy as well as absence of training on hygienic milk production in the current findings might have contributed for the production of poor quality milk in the study area. Therefore, there is a necessity to improve the hygienic status of milk being produced in the study area through training and consultancy of milk producers on general hygienic practices to be followed during milk production.

3.2. Management of Herd Health

About 52.5 and 32.5% of the respondents in pastoral and agro-pastoral production systems, respectively, vaccinate their herd twice per year; while about 36.3 and 61.3% of the respondents in pastoral and agro-pastoral production systems, respectively, vaccinate their herd thrice per year. These frequencies were significantly different ($P = 0.007$) (Table 2).

The majority of the respondents in pastoral (78.8%) and agro-pastoral (68.7%) production systems indicated that they do not discard milk from sick cow. They rather kept together with milk from healthy cows, and used for home consumption and market (Table 2). The finding is contradicted with the report of (Mosalagae et al., 2011) who indicted that most farmers interviewed dispose-off milk harvested from sick cows in Zimbabwe. This difference might be due to the difference in the level of awareness about animal diseases and the likely consequences that may emanate from consumption of contaminated milk. Failure to discard milk from sick cows contaminate the milk with spoilage and pathogenic microorganisms as cow infected with disease has high potential to shed large numbers of spoilage and pathogenic microorganisms into the milk (Pandey and Voskuil, 2011).

This study showed that about 43.8% of the respondents in agro-pastoral production system discard milk from diseased teats, which was significantly ($P = 0.03$) higher compared to that of pastoral production system (22.5%) (Table 2). Among milk producers reported to discard milk from diseased teats in both production systems, none of them dispose contaminated milk in appropriate place rather dispose on the floor of milking areas. According to Pandey and Voskuil (2011), disposing contaminated milk on the floor of milking and night holding areas increases the danger of milk contamination with microorganisms.

All respondents in pastoral and agro-pastoral production systems medicate their cattle when the animals get

Table 2: Management of herd health and milk from sick cows in pastoral and agro-pastoral production systems in Babile district (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Frequency of vaccination per year										
Once	11.3	6.25	8.75	10.0	0.007	7.5	10.0	8.75	0.98	0.61
Twice	52.5	32.5	42.5			40.0	45.0	42.5		
Thrice	36.3	61.3	48.8			52.5	45.0	48.8		
Sick cattle from the herd										
Culled always	8.75	8.13	12.5	2.53	0.28	13.75	11.25	12.5	2.23	0.32
Culled sometimes	22.5	25.0	23.75			18.75	28.75	23.75		
Not culled at all	68.75	58.75	63.75			67.50	60.0	63.75		
Milk from sick cows (except for teats/udders disease)										
Not milked at all	21.2	31.3	26.3	2.07	0.15	33.7	31.2	32.5	0.11	0.74
Milked and used both for home and market	78.8	68.7	73.8			66.3	68.8	67.5		
Milk from diseased teats/udders										
Milked but discarded	22.5	43.8	33.1	8.96	0.03	31.3	35.0	33.1	0.47	0.93
Milked and used for home consumption	18.8	13.7	16.3			17.5	15.0	16.3		
Milked and used both for home and market	52.5	35.0	43.8			45.0	42.5	43.8		
Not milked at all or left for calf	6.25	7.5	6.88			6.25	7.5	6.88		
Medicate your cattle when they get sick										
Yes	100	100	100	-	-	100	100	100	-	-
No	0.0	0.0	0.0			0.0	0.0	0.0	-	-
Medication of sick cattle is commonly done by										
Farmers	65.0	36.2	50.6	13.2	0.001	56.2	45.0	50.6	2.03	0.15
Animal health workers	35.0	63.8	49.4			43.8	55.0	49.4		
Milk from cows on medication BDWP										
Used both for consumption and market	82.5	62.5	72.5	8.03	0.005	76.2	68.8	72.5	1.13	0.29
Not used at all	17.5	37.5	27.5			23.8	31.2	27.5		

BDWP=before drug withdrawal period; PPS=Pastoral production system;
APPS=Agro-pastoral production system; SSH=small size herd; MSH=medium size herd

sick. However, the medication practices in pastoral production system were mainly performed by farmers themselves (65.0%), which was significantly (P = 0.001) higher compared to that of agro-pastoral production system (36.2%) (Table 2). According to Lore et al. (2006), sick animals should be medicated by a qualified animal health worker as such practice highly improve the health condition of animals, and consequently, improve the microbiological quality and safety of milk.

The majority (82.5%) of respondents in pastoral production system indicated that they use (either for home consumption or market) milk from cows on medication before drug withdrawal periods, which was significantly (P = 0.005) higher as compared to that of agro-pastoral production system (62.5%) (Table 2). The main reason for using milk from cows on medication before drug withdrawal period in the present study could be due to lack of knowledge on the withdrawal period of different drugs as well as due to lack of awareness on drug residues and the associated public health effects. According to Lore et al. (2006), milk from animals on medication should not be consumed or sold until the withdrawal period has elapsed. This is because consumers keep on ingesting low doses of drugs like antibiotics in form of residues which lead to development of antibiotic resistant strains as a consequence. Moreover, exposures to drug residues like antibiotic cause human health problems such as allergic reactions in sensitive people, toxicity and carcinogenic effects (Katakweba et al., 2012).

3.3. Housing Practices and Hygiene

All respondents in pastoral and agro-pastoral production systems keep their cattle in separate corral nearby owners' homes (Table 3). The finding contradicts with the report of Bereda et al. (2012) who indicated that majority (90.8%) of the respondents in Ezha district, Ethiopia, shared the same house with their animals. The purposes of housing cattle in

the study area were to protect them from predators and ease the husbandry practices.

Lactating and pregnant cows were kept in the same corral with other herds by the majority of respondent milk producers in pastoral (88.8%) and agro-pastoral (80.0%) production systems (Table 3). According to Kanyeka (2014), holding lactating animals (like cow) together with other herds in the same corral especially during the wet season enhance the risk of mastitis as well as milk contamination with spoilage and pathogenic microbes. The risk is very serious for large size herd than for small size herd (Sidibe et al., 2004).

About 35.0 and 38.8% of respondents in pastoral and agro-pastoral production systems, respectively, were cleaning the corral once a week, while about 27.5 and 20.0% of respondents in pastoral and agro-pastoral production systems, respectively, were not cleaning the corral at all (Table 3). According to Heuvelink et al. (2007)), night enclosure areas should be cleaned regularly (at least once a day) and free from the accumulations of manure, mud or any other objectionable materials to produce milk of good microbiological quality.

The study indicated that, all of the observed corrals have no roof and constructed on earthen floor, with poor drainage condition and difficult to clean and often were contaminated with mud, dung and urine especially during the rainy seasons. Moreover, none of the observed corrals was provided with comfortable bedding condition. This undoubtedly results in soiling of teats, udders, flank and other body part of milking cows while they are lying in muddy corrals, and cause the microbial contamination of milk during milking especially when udder and teats were poorly cleaned before milking. Practices that expose the teat end to waste, wet and muddy pens increase the risk of occurrence of mastitis and milk contamination with spoilage and pathogenic microbes (Ruegg, 2006).

3.4. Personal Hygiene of Milkers

The study indicated that, majority of the respondents in pastoral (72.5%) and agro-pastoral (77.5%) production systems milk the animals while showing disease symptoms (like diarrhea, runny nose, infected cuts or lesions on the hands, persistent coughing and sneezing) (Table 4). The person showing disease symptoms should not participate on milk handling operation as such person has high risk of contaminating milk with microorganisms (Musa et al., 2003).

The majority of respondent milkers in pastoral (50.0%) and agro-pastoral (62.5%) production systems wash their hand with cold water before milking, whereas some from pastoral (11.2%) and agro-pastoral (11.3%) production systems wash with warm water before milking. Among milkers reported to wash their hands before milking, none of them use detergent for hand washing (Table 4). According to Karabudak et al. (2008) and (Yilma, 2012), washing hands with cold or warm water without detergent lead to insufficient cleaning to remove germs as well as dirt, and become a possible source for the microbial contamination of food including milk.

Among respondents who reported to wash their hands before milking, majority of them were not drying their hand at all before milking rather were using wet hand while milking (Table 4). This practice adds spoilage and pathogenic microorganisms into the milk as drop of water from insufficient cleaned wet hands may enter into the milk during the process of milking (Omemu and Aderoju, 2008). It is, therefore, important that milkers should avoid the use of wet hand while milking.

Among milkers who reported to dry their hand before milking, none was using clean towels for hand drying rather they were drying their hands by wiping on the body of calf and milking cow as well as on their own clothes. This could be due to lack of knowledge on hygienic milk production practices, and undoubtedly cause the microbial contamination of milk from the milker's hands. According to Yilma (2012), milkers should always dry their hand with towels after washing before milking since such practices reduce the risk of milk contamination with microorganisms from milker's hand.

On the other hand, some of the respondents in pastoral (38.8%) and agro-pastoral (26.2%) production systems do not wash their hand before milking. Similarly, majority of the respondents in pastoral (66.3%) and agro-pastoral (50.0%) production systems do not wash their hands at all between milking (Table 4). This could be attributed to lack of awareness, and become possible source for milk contamination with both spoilage and pathogenic microorganisms. According to Al Suwaidi and Wasfy (2015), failure to properly wash hands before and between milking increases the risk of milk contamination with spoilage and pathogenic microorganisms during milking.

The majority of observed milkers in pastoral (92.5%) and agro-pastoral (88.7%) production systems were exposed to the variety of risk factors (like nose picking, touching rope and chair, scratching different parts of the body like mouth, ears, face, hairs and other body parts as well as wiping hands on the body of milking cows, calves and on their own clothes) while milking (Table 4). Among milkers exposed to the variety of risk factors during milking, none was washing their hands after exposure rather were using contaminated hands while milking. This may be due to lack of awareness and become a possible source for contamination of milk with both spoilage and pathogenic microbes. According to Mbabazi (2005), nose picking, touching hair and scratching mouth, ears, face and any part of the body while milking may increase the risk of milk contamination with spoilage and pathogenic microorganism. It is, therefore, important that milkers should avoid exposure to the variety of risk factors before and during milking.

The majority of the respondents in pastoral (61.3%) and agro-pastoral (53.7%) production systems were not taking precautions to avoid coughing or sneezing over milk or milking equipment while milking (Table 4). According to (Kurwijila et al., 2006), habits like coughing or sneezing

Table 3: Cattle housing practices and corral hygiene in pastoral and agro-pastoral production systems in Babile district (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Cattle housing system										
Separate enclosure (corral)	100	100	100	-	-	100	100	100	-	-
With family	0.0	0.0	0.0			0.0	0.0	0.0		
Season of housing										
Throughout the year	81.3	77.5	79.4	2.56	0.28	77.5	81.3	79.4	0.35	0.84
Wet season	8.75	16.2	12.5			13.7	11.3	12.5		
Dry season	10.0	6.3	8.13			8.75	7.5	8.13		
Housing of lactating and pregnant cows										
Housed together with other herds	88.8	80.0	84.4	2.32	0.13	81.3	87.5	84.4	1.19	0.28
Housed separately	11.2	20.0	15.6			18.7	12.5	15.6		
Frequency of cleaning of cattle house										
Once per week	35.0	38.8	36.9	4.24	0.24	40.0	33.8	36.9	1.77	0.62
Twice per week	26.2	20.0	23.1			25.0	21.2	23.1		
More than twice per week	11.3	21.2	16.3			15.0	17.5	16.3		
Not at all	27.5	20.0	23.8			20.0	27.5	23.8		
Floor of night holding area										
Soiled	100	100	100	-	-	100	100	100	-	-
Graveled	0.0	0.0	0.0			0.0	0.0	0.0		
Bedding materials										
Not provided at all	100	100	100			100	100	100		

PPS = Pastoral production system; APPS = Agro-pastoral production system;
SSH = Small size herd; MSH = Medium size herd

over milk or milk equipment while milking increase the risk of milk contamination with microorganisms. Moreover, none of the observed milkers in both production systems was dressing clean outer garment while milking. According to Yilma (2012), covering hair and dressing gown (clean outer garment) while milking is an important practice that milkers need to obey as this practice prevents the milk from microbial contamination.

3.5. Milking Equipment and Sanitary Practices

Plastic equipment was commonly used as milking utensil by the majority of milkers in pastoral (48.7%) and agro-pastoral (52.5%) production systems. Some from pastoral (26.3%) and agro-pastoral (21.3%) production systems were commonly using traditionally prepared equipment, which are made from wood (locally named as Okole) and cucumber (locally named as Qabe) as milking utensils (Table 5). The finding disagrees with (Lumadede et al., 2010) who indicated that the majority (71%) of milkers in Dollo Ado district, Ethiopia used traditionally prepared equipment as milking utensils. The use of plastic and traditional prepared equipment as milking utensil is not advisable as they become potential source for the microbial contamination of milk during milking (Pandey and Voskuil, 2011). Aluminum cans and stainless steel equipment are the preferred milking utensils (Zelalem, 2003).

About 43.8 and 35.0% of the respondents in pastoral and agro-pastoral production systems, respectively, were using cold water and detergent (Ajax soap or leaves of Lantena camara) to wash milking equipment before milking, while some from pastoral (20.0%) and agro-pastoral (25.0%) production systems were using cold water without detergent (Table 5). The use of cold water with or without detergent for cleaning of milking equipment may not remove germs and become a possible source for the microbial contamination of milk during milking (Karabudak et al., 2008).

None of the respondent milkers in both production systems was using appropriate material for the action of physical scrubbing of milking equipment while washing rather were using clothes or sponges or leaves of Lantana camara and Olea africana (Table 5). The use of clothes or sponges for physical scrubbing of milk equipment is not recommendable as they are not strong enough for proper scrubbing of milk contact surfaces and often spread germs, and become a major source for the contamination of milk with microorganisms (Hilton and Austin, 2000; Haysom and Sharp, 2005; Byrd-Bredbenner et al., 2013). Moreover, some respondents were using sands for the action of physical scrubbing of milking equipment. This causes scratching of the internal surface of plastic and traditional equipment, and increases the chance for microorganism to attach to the surface and form a biofilm, which could serve as a source for the contamination of milk with microorganisms while milking (Orregård, 2013).

All respondents in pastoral and agro-pastoral production systems were fumigating milking equipment with smoke from burning stems of specific plant species such as Ejersa (Olea africana), Bir'eensa (Terminalia brownie), Mi'eessaa

Table 4: Personal hygiene of milkers in pastoral and agro-pastoral production systems in Babile district (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Practice of milking cows while showing disease symptoms										
Stopped always	16.3	7.50	11.9			16.3	7.50	11.9		
Stopped sometimes	11.2	15.0	13.1	3.14	0.21	10.0	16.2	13.1	3.80	0.15
Not stopped at all	72.5	77.5	75.0			73.7	76.3	75.0		
Practice of washing hands before milking										
Commonly done with cold water only	50.0	62.5	56.3			53.7	58.7	56.2		
Commonly done with warm water only	11.2	11.3	11.2	3.03	0.22	15.0	7.50	11.3	2.25	0.32
Not washed at all	38.8	26.2	32.5			31.3	33.8	32.5		
Method of drying hands after washing										
By wiping on the body cow/on calf	20.0	15.4	17.7			17.9	17.6	17.7		
By wiping on their own clothes	12.5	19.2	15.8	4.39	0.22	13.1	18.9	15.8	1.82	0.61
Not dried at all	28.8	38.5	33.5			32.1	35.1	33.5		
Hands washing between milking										
Performed always	2.50	5.0	3.80			3.8	3.8	3.8		
Performed some times	31.2	45.0	38.1	4.47	0.11	35.0	41.2	38.1	0.68	0.71
Not washed at all	66.3	50.0	58.1			61.2	55.0	58.1		
Exposure to risk factors while milking										
Avoided	7.50	11.8	9.4	0.66	0.415	6.3	12.5	9.4	1.84	0.18
Not avoided	92.5	88.7	90.6			93.7	87.5	90.6		
Coughing/sneezing over milk and milking equipment while milking										
Avoided	38.7	46.3	42.5	0.92	0.34	37.5	47.5	42.5	1.64	0.20
Not avoided	61.3	53.7	57.5			62.5	52.5	57.5		

PPS = Pastoral production system; APPS = Agro-pastoral production system;
SSH = Small size herd; MSH = Medium size herd

(Euclea schemperi) and Jimaa (Catha edulis) following washing (Table 5). After smoking, none of the observed milkers in both production systems was properly protecting milking equipment from risk factors (like flies, dusts and other contaminant agents) while handling for the next time milking. This might be due to lack of awareness and proper training on milk hygiene and quality.

3.6. Udder Preparation and Milking Techniques

The majority of the respondents in pastoral (85.0%) and agro-pastoral (71.2%) production systems were restraining only aggressive milking cows while milking, whereas the remaining respondents from pastoral (15.0%) and agro-pastoral (28.8%) production systems were always restraining cows while milking. The frequencies for the practices of restraining milking cows were significant (X2 = 4.43, P = 0.04) (Table 6). According to Mbabazi (2005), milking cow should always be restrained prior to milking. This is because cows carry a lot of dust or mud from the stable on their body. During milking process, a lot of this dust and other dirt will be dislodged by the constant waving of the tail to drive away flies and fall into milk, and become a possible source for milk contamination.

Calf suckling was commonly used by the majority of respondent milkers in pastoral (92.5%) and agro-pastoral (86.3%) production systems as a method of cleaning teats before milking as they believe that teats will be washed by the saliva of calf during suckling. However, such cleaning practices will lead to insufficient cleaning to remove dirt and germs from udder and teat, and allow entry of spoilage and pathogenic microorganisms into milk while milking (Gran et al., 2003; Yilma, 2012). Once the microorganisms get accesses to enter into raw milk, they can easily multiply and deteriorate the quality of raw milk making it unsafe for its intended use. Thus, proper udder and teat cleaning before milking is one of the most important hygienic practices required to ensure clean milk production (Gran et al., 2003; Yilma, 2012).

After cleaning teats, about 40.0 and 30.0% of the respondents in pastoral and agro-pastoral production systems, respectively, were drying teats with hairs found on the end of tail. Moreover, about 35.0 and 48.8% respondents in pastoral and agro-pastoral production systems, respectively, were using improperly cleaned bare hands to dry teats before milking, while some from pastoral (8.75%) and agro-pastoral (6.25%) production systems were using own wearing clothes (Table 6). This could be attributed to lack of awareness and may become possible source for the contamination of milk with spoilage and pathogenic microorganism.

Table 5: Equipment used for milking and sanitary practices performed by milk producers in the Babile district (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Type of equipment commonly used for milking										
Plastic equipment	48.7	52.5	50.6	0.56	0.76	43.7	57.5	50.6	4.15	0.13
Traditionally prepared equipment	26.3	21.3	23.8			30.0	17.5	23.8		
Aluminum cans	25.0	26.2	25.6			26.3	25.0	25.6		
Frequency of cleaning milking equipment										
Twice (before and after milking)	100	100	100	-	-	100	100	100	-	-
Washing before milking is commonly done with										
Cold water only	20.0	25.0	22.5	4.15	0.25	21.2	23.8	22.5	0.31	0.96
Cold water with Ajax soap/leaves of LC	43.8	35.0	39.4			41.3	37.5	39.4		
Warm water only	13.7	7.50	10.6			10.0	11.2	10.6		
Warm water with Ajax soap/leaves of LC	22.5	32.5	27.5			27.5	27.5	27.5		
Commonly used method of washing after milking										
Cold water with Ajax soap/leaves of LC	51.3	47.5	49.4	0.23	0.64	50.0	48.8	49.4	0.03	0.87
Warm water with Ajax soap/leaves of LC	48.7	52.5	50.6			50.0	51.2	50.6		
Physical scrubbing is common done with										
Clothes or sponge or nylon	42.5	41.3	41.9	2.59	0.27	37.5	46.3	41.9	2.03	0.36
Sand and cloth or sponge or nylon together	6.3	13.7	10.0			8.80	11.2	10.0		
Leaves of Lantana camara or Olea africana	51.2	45.0	48.1			53.7	42.5	48.1		
Commonly used plant materials for smoking										
Ejersa* (Olea africana)a	43.8	41.2	42.5	3.16	0.37	42.5	42.5	42.5	1.39	0.71
Mi'eessaa* (Euclea schemperi)a	12.5	21.3	16.9			17.5	16.3	16.9		
Bir'eensa*(Terminalia brownii)a	32.5	23.7	28.1			25.0	31.2	28.1		
Jimaa*(Catha edulis)a	11.2	13.8	12.5			15.0	10.0	12.5		

LC = Lantana Camara; PPS = Pastoral production system; APPS = Agro-pastoral production system;
SSH = Small size herd; MSH = Medium size herd;
*Localname; Scientific name; Traditionally prepared equipment is equipment made from wood and cucumber

On the other hand, some respondents from pastoral (16.2%) and agro-pastoral (15.0%) production systems were not drying teats at all after cleaning before milking to facilitate lubrication for hand strip milking (Table 6). According to Mbabazi (2005), wet teat milking should be avoided as organisms present on milkers' hands and teats are washed into milk during the process of milking, and will affect the microbiological quality and safety of raw milk at farm level. Ruegg (2006) also indicated that, milking wet teats allows skin and environmental bacteria to have easy access into mammary gland and cause the occurrence of mastitis, which leads to contamination of milk with spoilage and pathogenic bacteria.

None of the respondents in the study area were following pre and post teat dip procedures. Even, sometimes some milk producers were smearing teats with dung after milking as a means of preventing calves from suckling the dam while grazing. On the next milking, the cow is given its calf to suckle and milking follows without cleaning the teats which introduces dung particles into the milk. This may have its own contribution on the microbial contamination of milk during milking. According to Kamal and Bayoumi (2015), pre and post teat dipping procedures is important to remove both visible dirt and bacteria from the outer surface of the teat, and hence reduce the risk of environmental mastitis as well as milk contamination with microorganisms. Milk producers should, therefore, perform pre and post teat dipping practices regularly to minimize milk contamination with spoilage and pathogenic microorganisms.

Table 6: Restraining milking cow, udder preparation, order of milking and checking milk for abnormalities before actual milking (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Practices of restraining cows before milking										
Done only for aggressive milking cows	85.0	71.2	78.1	4.43	0.04	86.2	70.0	78.1	6.18	0.01
Done for all milking cows	15.0	28.8	21.9			13.8	30.0	21.9		
The most common method of cleaning udder/teats before milking										
Washing with cold water only	5.00	8.75	6.88			10.0	3.75	6.88		
Washing with cold water and detergent	2.50	5.00	3.75	-	0.45	1.25	6.25	3.75	-	0.11
Calf suckling	92.5	86.3	89.4			88.8	90.0	89.4		
After cleaning, teats were commonly dried with				3.32	0.34				1.21	0.75
Own wearing clothes	8.75	6.25	7.50			7.5	7.50	7.50		
Bare hand	35.0	48.8	41.9			43.8	40.0	41.9		
Hairs found at the end of the tail	40.0	30.0	35.0			36.2	33.8	35.0		
Not dried at all	16.2	15.0	15.6			12.5	18.7	15.6		
Checking milk for abnormality before milking										
Performed always	8.8	21.3	15.0			13.7	16.3	15.0		
Performed sometimes	65.0	63.8	64.4	6.63	0.04	62.5	66.3	64.4	0.20	0.66
Not performed at all	26.3	15.0	20.6			23.8	17.5	20.6		
Order of milking between healthy and diseased teats				-	0.68				-	0.88
Milk healthy teats first	60.0	52.5	56.3			55.0	57.5	56.3		
Milk diseased teats first	0.0	0.0	0.0			0.0	0.0	0.0		
Diseased teats were not milked at all	6.3	7.50	6.88			6.25	7.50	6.88		
No order of milking	33.7	40.0	36.9			38.7	35.0	36.9		

PPS = Pastoral production system; APPS = Agro-pastoral production system;
SSH = Small size herd; MSH = Medium size herd

The majority of the respondents in pastoral (65.0 %) and agro-pastoral (63.8%) production systems were checking the milk sometimes for the abnormalities in each quarter before milking. Moreover, about 26.3 and 15.0% of the respondents in pastoral and agro-pastoral production systems, respectively, were not checking the milk at all for the abnormalities before milking (Table 6). The main reasons for the absence of checking milk always for the abnormalities before milking by the majority of respondents in the present study might be due to lack of awareness and could be a possible source for the contamination of milk with microorganisms while milking. According to Lore et al. (2006) and Pandey and Voskuil (2011), milkers should always check the milk for the abnormalities (like for the presence of discoloration, clots, blood and bad odder) before actual milking since such practice minimizes the contamination of milk with spoilage and pathogenic microorganisms at farm level through preventing the mixing of milk from sick and healthy cows during milking.

This study indicated that, all of the observed milk producers in both production systems were practicing hand strip (pull-down) milking technique. According to Kurwijila (2006), hand strip milking technique is a known technique in increasing the microbial content of milk. This is because such milking technique helps pushing of visible and non-visible dirt found on the exterior part of improperly cleaned and dried teats into the milking container while milking. The overall milking operations in the study area were carried out by women (household wives or adult girls). Therefore, gender education on hygienic milk production practices in the study area is highly important. This will have two important benefits: consumers will have access to clean, wholesome and nutritious milk, and producers fetch better income from the sale of good quality milk and milk products.

None of the respondents in the study area had separate milking place rather were milking cows at any available open places. This practice increases the risk of milk contamination with dust particles, pieces of straw/grass and feed materials which may land into the milk when wind blows while milking, and leads to the contamination of milk with spoilage and pathogenic microorganisms during milking (Yilma, 2012).

3.7. Source of Water and Method of Treatment Used for Hygienic Practices

The majority (60%) of respondents in pastoral production system were using water from non-tap sources (such as

Table 7: Source and treatment method of water used for hygienic practices in the study area (%)

Variable	Production System					Herd size group				
	PPS n=80	APPS n=80	Total N=160	X^2	P value	MSH n=80	SSH n=80	Total N=160	X^2	P value
Source of water										
Open water supply*	60.0	43.8	51.9	4.23	0.04	52.5	51.3	51.9	0.03	0.87
Hand pipe	40.0	56.2	48.2			47.5	48.7	48.1		
Method of treatment before use										
Physical/boiling	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-
Chemical	0.0	0.0	0.0			0.0	0.0	0.0		
Not at all	100	100	100			100	100	100		

PPS=Pastoral production system; APPS=Agro-pastoral production system; SSH=Small size herd; MSH=Medium size herd; *Open water supply includes wells,spring,river,stream and water collected from flood

wells, spring, stream, river and water collected from flood) for hygienic practices, which was significantly ($x^2 = 4.23$, P = 0.04) higher compared to that of agro-pastoral production system (43.8%) (Table 7). The finding is relatively comparable with the report of Bereda et al. (2012) who found that the majority (57%) of the respondents in Ezha district of the Gurage zone, Ethiopia used water from non-tap sources (like rivers and streams) for hygienic practices. According to Jayarao et al. (2004), using water obtained from non-tap sources for hygienic practices during food (like milk) production and handling may leads to contamination of the food with spoilage and pathogenic microorganisms. Thus, water used for hygienic practices should be of potable quality (Zelalem, 2003). If it is difficult to obtain water of potable quality, water obtained from non-tap sources should be treated (either chemically or physically) prior to use for hygienic practices (Bereda et al., 2012; Yilma, 2012). However, out of the respondents reported to use water from non-tap sources for hygienic practices, none was treating prior to use, which is relatively comparable with the finding of Gurmessa (2015) who reported that the majority (75.6%) of the respondents in Yabello District, Ethiopia were not treating wash-water prior to use for hygienic practices. It is, therefore, important to heat or chemical treat wash-water from non-tape sources prior to use.

4. Conclusion

The study showed that the majority of respondents in pastoral and agro-pastoral production systems in Babile district were illiterate, and lack capacity to produce hygienic milk. Failure to discard milk from sick cow and cows on medication were common. All respondents were keeping milking cows in corrals lacking roof, constructed on earthen floor, difficult to clean and contaminated with mud, dung and urine especially during rainy season. Malpractices such as failure to stop milking while showing disease symptoms, wash hands between each milking, stop handling of risk factors while milking were common. The most widely used milking utensil was plastic equipment, and the most common washing practice employed was the use of cold water and detergents. In most cases milking utensils were not properly protected from risk factors (like flies, dusts, etc) after cleaning. Most respondents in both production systems were not properly washing udder and teats before milking rather were using calf suckling as a method of cleaning teats before milking. The majority of the respondents in pastoral and some from agro-pastoral production systems were using water from non-tap sources. Moreover, none of the respondents was treating wash-water prior to use for hygienic practices. In general, it could be concluded that, the milk production practices performed in the study area were unhygienic which could be mainly due to lack of knowledge on hygienic milk production practices. Therefore, the concerned governmental and non-governmental institutions should pay attention to the improvement of hygienic practices through undertaking relevant development interventions.

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References

Al Suwaidi, Hussein, A. F. E. and Wasfy (2015). Hygienic practices among food handlers in dubai. *International Journal of Preventive Medicine Research*, 1:101–108.

Ali, A. A., Irshad, N., Razaz, S., Manahil, A., et al. (2010). Microbiological safety of raw milk in khartoum state, sudan: 1-khartoum and omdurman cities. *Pakistan Journal of Nutrition*, 9(5):426–429.

Bereda, A., Yilma, Z., and Nurfeta, A. (2012). Hygienic and microbial quality of raw whole cow's milk produced in ezha district of the gurage zone, southern ethiopia. *Wudpecker Journal of Agricultural Research*, 1(11):459–465.

Bramley, A. (1990). Microbiology of raw milk. *Dairy microbiology*, 1:163–208.

Byrd-Bredbenner, C., Berning, J., Martin-Biggers, J., and Quick, V. (2013). Food safety in home kitchens: a synthesis of the literature. *International journal of environmental research and public health*, 10(9):4060–4085.

Chambers, J. (2002). *The microbiology of raw milk , Dairy Microbiology Handbook, New York, USA*. 3rd edition.

Coorevits, A., De Jonghe, V., Vandroemme, J., Reekmans, R., Heyrman, J., Messens, W., De Vos, P., and Heyndrickx, M. (2008). Comparative analysis of the diversity of aerobic spore-forming bacteria in raw milk from organic and conventional dairy farms. *Systematic and Applied Microbiology*, 31(2):126–140.

CSA (Central Statistical Agency) (2008a). Federal democratic republic of ethiopia, central statistical agency,addis ababa, ethiopia. population projection of ethiopia for the year 2014.

CSA (Central Statistical Agency) (2008b). Statistical abstract 2007, addis ababa, ethiopia, east hararghe zone profile 2009. https://www.oromiagov.org/socio%20Economic%20profile/East%20Hararghe%20zone/East%20Hararghe%20zone.doc.

Dayanandan, R. (2011). Production and marketing efficiency of dairy farms in highland of ethiopia-an economic analysis. *International Journal of Enterprise Computing and Business Systems*, 1(2):1–34.

Demissie, B., Hussien, H., and Kedir, A. (2015). Structure, conduct and performance of marketing chains: The case of milk marketing among pastoralists and agropastoralists of eastern ethiopia. *Global Journal of Agricultural Economics, Extension and Rural Development*, 3(3):206–213.

Development, B. D. L. and Agency, H. (2015). Annual report on livestock production potential in babile district, ethiopia.

Fitzhugh, H. 1999. Foreword. In: Falvey, L. and Chantalakhana, C. e. (1999). Smallholder dairying in the tropics. international livestock research institute,. *Thailand Research Fund, Institute of Land and Food Resources*.

Gran, H., Wetlesen, A., Mutukumira, A., Rukure, G., and Narvhus, J. (2003). Occurrence of pathogenic bacteria in raw milk, cultured pasteurised milk and naturally soured milk produced at small-scale dairies in zimbabwe. *Food control*, 14(8):539–544.

Gurmessa, T. (2015). Microbiological quality and impact of hygienic practices on raw cow's milk obtained from pastoralists and market. the case of yabello district, borana zone, ethiopia. *Global Journal of Food Science and Technology*, 3:153–158.

Haysom, I. and Sharp, A. (2005). Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal*, 107(7):453–466.

Heuvelink, A., Valkenburgh, S., Tilburg, J., Van Heerwaarden, C., Zwartkruis-Nahuis, J., and De Boer, E. (2007). Public farms: hygiene and zoonotic agents. *Epidemiology & Infection*, 135(7):1174–1183.

Hilton, A. and Austin, E. (2000). The kitchen dishcloth as a source of and vehicle for foodborne pathogens in a domestic setting. *International Journal of Environmental Health Research*, 10(3):257–261.

Javaid, S., Gadahi, J., Khaskeli, M., Bhutto, M., Kumbher, S., and Panhwar, A. (2009). Physical and chemical quality of market milk sold at tandojam, pakistan. *Pakistan Veterinary Journal*, 29(1).

Jayarao, B., Pillai, S., Sawant, A., Wolfgang, D., and Hegde, N. (2004). Guidelines for monitoring bulk tank milk somatic cell and bacterial counts. *Journal of dairy science*, 87(10):3561–3573.

Kamal, R. and Bayoumi, M. (2015). Efficacy of premilking and postmilking teat dipping as a control of subclinical mastitis in egyptian dairy cattle. *International Food Research Journal*, 22(3).

Kanyeka, H. B. (2014). *Assessment of microbial quality of raw cow's milk and antimicrobial susceptibility of selected milk-borne bacteria in Kilosa and Mvomero districts, Tanzania*. PhD thesis, Sokoine University of Agriculture.

Karabudak, E., Bas, M., and Kiziltan, G. (2008). Food safety in the home consumption of meat in turkey. *Food Control*, 19(3):320–327.

Katakweba, A., Mtambo, M., Olsen, J. E., and Muhairwa, A. (2012). Awareness of human health risks associated with the use of antibiotics among livestock keepers and factors that contribute to selection of antibiotic resistance bacteria within livestock in tanzania. *Livestock Research for Rural Development*, 24(10):170.

Kivaria, F., Noordhuizen, J., and Kapaga, A. (2006). Evaluation of the hygienic quality and associated public health hazards of raw milk marketed by smallholder dairy producers in the dar es salaam region, tanzania. *Tropical Animal Health and Production*, 38(3):185–194.

Kuma, A., Abdisa, M., and Tolossa, D. (2015). Evaluation of hygienic status and marketing system of raw cow milk in different critical points of oromia special zone. *Global Journal of Science Frontier Research: C Biological Science*, 15:21–30.

Kuma, B., Baker, D., Getnet, K., and Kassa, B. (2013). Factors affecting milk market outlet choices in wolaita zone, ethiopia. *African Journal of Agricultural Research*, 8(21):2493–2501.

Kurwijila, L. R. (2006). Hygienic milk handling, processing and marketing: reference guide for training and certification of small-scale milk traders in eastern africa.

Kurwijila, L. R., Omore, A., Staal, S., and Mdoe, N. (2006). Investigation of the risk of exposure to antimicrobial residues present in marketed milk in tanzania. *Journal of food protection*, 69(10):2487–2492.

Lore, T. A., Kurwijila, L. R., and Omore, A. O. (2006). Hygienic milk production: a training guide for farm-level workers and milk handlers in eastern africa.

Lumadede, A., Owuor, G., Laqua, H., and Gluecks, I. (2010). Pastoral milk production and market chain analysis in dollo ado and dollo bay, somali region of ethiopia for save the children. *US-Version*, 1:1–34.

Mbabazi, P. (2005). *Milk industry in Uganda.* Fountain Publishers, Kampala, Uganda, 1st edition.

Melesse, K., Agza, B., and Melesse, A. (2014). Milk marketing and post harvest loss problem in ada'a and lume districts of east shoa zone, central ethiopia. *Sky Journal of Food Science*, 3(4):027–033.

Mosalagae, D., Pfukenyi, D. M., and Matope, G. (2011). Milk producers' awareness of milk-borne zoonoses in selected smallholder and commercial dairy farms of zimbabwe. *Tropical animal health and production*, 43(3):733–739.

Musa, O., Akande, T., et al. (2003). Food hygiene practices of food vendors in secondary schools in ilorin. *The Nigerian Postgratuate Medical Journal*, 10(3):192–6.

Omemu, A. and Aderoju, S. (2008). Food safety knowledge and practices of street food vendors in the city of abeokuta, nigeria. *Food control*, 19(4):396–402.

Orregård, M. (2013). Quality analysis of raw milk along the value chain of the informal milk market in kiambu county, kenya.

O'Connor, C. (1995). Rural dairy technology ilri training manual i. *International Livestock Research Institute, Addis Ababa, Ethiopia*.

Pandey, G. and Voskuil, G. (2011). Manual on milk safety,quality and hygiene. *Golden Valley agricultural Research Trust, Zambia*, 52.

Ruegg, P. L. (2006). The role of hygiene in efficient milking. *WCDS Advances in Dairy Technology*, 18:285–293.

Sidibe, M., Boly, H., Lakouetene, T., Leroy, P., and Bosma, R. (2004). Characteristics of peri-urban dairy herds of bobo-dioulasso (burkina faso). *Tropical Animal Health and Production*, 36(1):95–100.

Soomro, A., Arain, M., Khaskheli, M., and Bhutto, B. (2002). Isolation of escherichia coli from raw milk and milk products in relation to public health sold under market conditions at tandojam. *Pakistan Journal of Nutrition*, 1(3):151–152.

System, S. A. (2008). *Statistics Analysis System user's Guide*. SAS Institute Inc., Cary, North Carolina, USA.

Torkar, K. G. and Teger, S. G. (2008). The microbiological quality of raw milk after introducing the two day's milk collecting system. *Acta Agriculturae Slovenica*, 92(1):61–74.

Welearegay, H., Yilma, Z., and Tekle-Giorgis, Y. (2012). Hygienic practices and microbiological quality of raw milk produced under different farm size in hawassa, southern ethiopia. *Agricultural Research and Review*, 1(4):1132–142.

Worku, T., Negera, E., Nurfeta, A., and Welearegay, H. (2014). Milk handling practices and its challenges in borana pastoral community, ethiopia. *African journal of agricultural research*, 9(15):1192–1199.

Yilma, Z. (2012). Microbial properties of ethiopian marketed milk and milk products and associated critical points of contamination: An epidemiological perspective. *Epidemiology insights*, 15:298–322.

Zelalem, Y. (2003). Sanitary conditions and microbial qualities of dairy products in urban and peri-urban dairy shed of the central ethiopia. *DEA. Lyon, France*.