

Full Length Research Paper

Milk handling practices and its challenges in Borana Pastoral Community, Ethiopia

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A total of 132 randomly selected milk producing households (HH's) were interviewed to assess milk handling and its challenges. The average household HH size of respondents was 7.76 (0.3) persons per family. The average land holding per households was 2.91 (0.08) hectare (ha). Natural pasture is a common feed source in the studied area. The average number of dairy cows per household HH was 2.06 (0.01) and varied from 1 to 50 cows. Okkicha kebele had the highest number (2.32) cows. The milking operation is usually conducted in the barn, in an open area and milking is performed twice a day (85%). All the studied households do not use towels for cleaning and drying cow's udder. Proper cleaning of milk handling equipment was not done in the majority (77.8%) of the pastoral households. The majority (83.34%) of the pastoral households use traditional dairy containers and the others (16.66%) make use of aluminium and plastics cans. The predominant washing practices (83.33%) were washing milk handling equipments by the use of water and leaves of shrubs. The results indicate that the milking and storage conditions was unhygienic, insufficient cleaning of milk handling equipments and poor quality water usage were some of the basic determinant of milk quality assessed in the study area. These results appear to suggest the need for improved hygienic practice at different level of milk production in the pastoral community.

Key words: Milk handling, challenges, Borana, Pastoral community, Ethiopia.

INTRODUCTION

Ethiopia holds the largest livestock population in Africa. The total national milk production remains among the lowest in the world, even by African standard. The total annual milk production in Ethiopia from 10.7 million milking cows is estimated at about 3.8 billion liters, and this translates to an average production of 1.32 L/cow

per day (CSA, 2013). In the Horn of Africa, pastoralists occupy large parts of arid and semi-arid lands of Ethiopia, Kenya, Somali, Djibouti, Eritrea, Sudan, Uganda, and Tanzania (FEWS NET/USAID, 2004). Together with agro-pastoralists they comprises significant proportions of national populations in each of these countries. Livestock

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ownership currently contributes to the livelihoods of an estimated 80% of the rural population. In the highlands, livestock are kept under settled or transhumant systems utilizing natural pasture. In the arid and semi-arid extensive grazing areas of the eastern, western, and southern lowlands, cattle, sheep, goats, and camels are managed in migratory pastoral production systems (FAO, 2005).

The estimated livestock population in pastoral districts also indicates that cattle are the prominent in population size (1,048,909) as an important specie and followed by goats (989,691), sheep (396,819) and camels (62,789) in order of population (CSA, 2013). The Borana breed, one of the multipurpose cattle breeds in Africa, was evolved, and is still widely reared by Borana pastoralists of Southern Ethiopia. According to Solomon (1999) the population of this breed living in the Borana pastoral areas is estimated at 1.7 million. Borana pastoralists' livelihoods depend predominantly on livestock and their products.

They practice a transhumance nomadic system which had been a primary survival strategy. The cattle herd is split into two groups: the '*Warra*' herd that comprises small number of animals specially milking cows and calves that are kept around the '*Olla's*' (permanent encampments); and the '*Forra*' herd that encompasses the majority of animals which are driven long distances in search of good pasture and surface water, irrespective of national boundaries (Coppock, 1994). As a pastoral community, milk is the main diet of the society in Borana Zone.

The physical infrastructure is poorly developed in areas where pastoralists live (FEWS NET/USAID, 2004). Milk and milk product handling in the area is more of a traditional type. There is little information available with regard to milk and milk products handling. Understanding the hygienic conditions of needed for milk and milk production and its challenges faced by the pastoral community in a given area is important to improve their wholesomeness and thereby provide quality and safe products to consumer as well as improve the income of farmers.

Therefore, the aim of the present study was to assess milk handling practices and its challenges in the Borana pastoral community.

MATERIALS AND METHODS

Study location

The study was carried out in Abaya district of Borana pastoral area of Oromia Regional State located at 366 km south east of Addis Ababa, between 03°37' 23.8" to 05° 02' 52.4" North and 37° 56' 49.4" to 39° 01' 101" East, in the Southern part of Ethiopia. The district represents a total area of 1205.28 km² and comprises 27 kebeles (the smallest administrative unit). The altitude ranges from 970 meter above sea level in the south bordering Kenya to 1693 meter above sea level in the Northeast. The climate is semi-arid,

with which receives annual average rainfall ranging from 500 mm³ in the south to over 700 mm³ in the north. The area receives bimodal rainfall, where 56% of the annual rainfall occurs from March to May and 27% from mid September to mid-November (Coppock, 1994). Annual mean daily temperature varies from 19 to 24°C with moderate seasonal variation.

Data collection

The study was conducted from June 2010 to May 2011. Pastoral community of six Kebeles were selected from 27 Kebeles of Abaya district using purposive sampling procedures based on their geographical location, proximity to fresh milk, and socioeconomic characteristics for this study.

The selected kebeles's were Debeke, Dibbicha, Golloicha, Ture Kejima, Okkicha and Wadye-Kejima. A total of 132 pastoral dairy households, 22 from each Kebele, were selected using simple random sampling technique for the survey study. A semi structured questionnaire which focused on the households attributes was used, including basic farm data (Socio-economic of characteristics, milk handling and hygienic practice) and other relevant information related to cow attributes such as number of lactating cow per households, udder preparation, animal housing systems and barn hygiene practices.

Data analysis

Descriptive statistics was used to evaluate the variables in the production, and milk handling practices using SPSS (2007) software (ver.16). The mean and percentage values of various parameters were compared across the studied kebeles.

RESULTS

Socio-economic characteristics of pastoral households

The average household HH size of the target respondents was 7.76 persons per family member size (Table 1). The average land holding of the overall study sites per household was 2.91 ± 0.08 ha.

Natural pasture, mineral licks, and cultivated pasture were common feed sources in the area. Okkicha Kebele had higher average grazing and crop land holding per households than the other rural kebeles (Figure 1). Both crop and fallow land was available only in Debeke kebele.

The average number of cows per household was 2.06 and varied from 1 to 50 cows. Among the studied six Kebeles, Okkicha had the highest number (2.32) of cows and the least (1.18) was for Debeke Kebele.

Educational status and religion of pastoral households

In this finding, there were more family members at elementary school level of education were higher than those at with higher educational level (Table 2), however, 58.3% of the respondents were illiterate. The majority of

Table 1. Mean (\pm SE) value of socio-economic characteristic of pastoral households of six Keble of Abaya District, Borana Pastoral Community.

Study Kebeles	HH's characteristics			
	Family size	Age structure	Land holding per HH ¹ (ha)	Lactating cows per HH ¹
Gololicha	7.05(0.7)	45.73(2.2)	2.93(0.2)	2.27(0.2)
Debeke	7.14(0.5)	44.73(3.1)	3.28(0.2)	1.18(0.1)
Dibbicha	9.0(0.9)	48.95(2.4)	2.71(0.2)	2.24(0.2)
Ture-Kejima	7.43(0.5)	42.35(1.9)	2.83(0.2)	2.22(0.2)
Okkicha	7.91(0.6)	42.14(2.9)	3.09(0.2)	2.32(0.2)
Wadye-Kejima	8.09(0.8)	43.68(3.5)	2.63(0.3)	2.14(0.2)
MeanTotal (N=132)	7.76(0.3)	44.55(1.1)	2.91(0.08)	2.06(0.01)

N=Number of respondents of each Keble of HH's; SE = standard mean error.

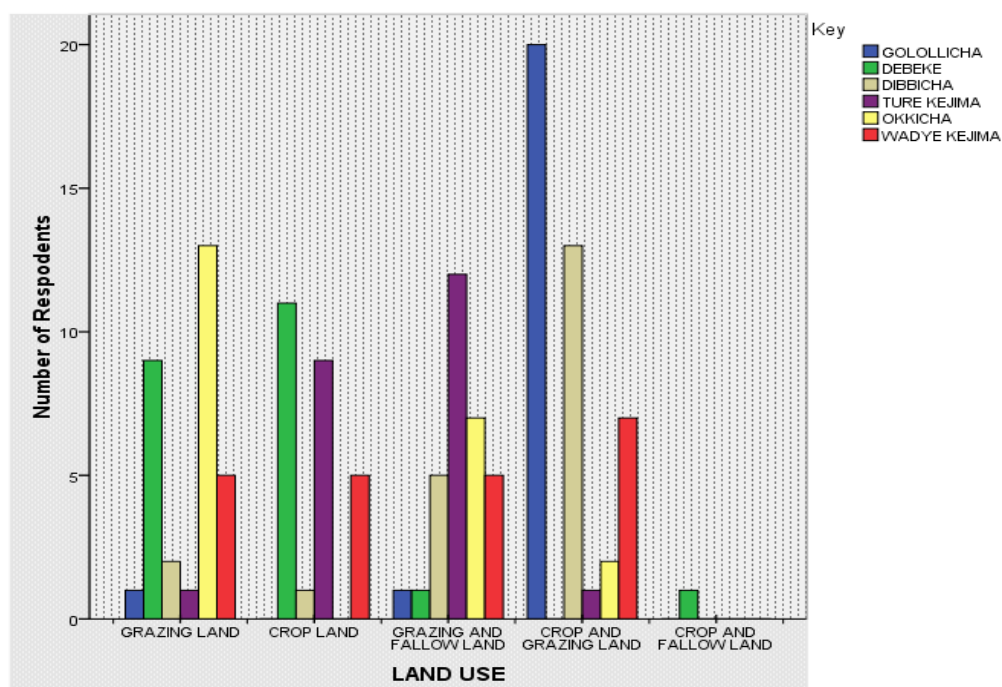


Figure 1. Land use pattern of the pastoral households of six Keble of Abaya District, Borana Pastoral Community.

the respondents (67.4%) were protestant Christian followed by Orthodox Christian.

Housing system and barn hygiene

According to the study, among the interviewed households, 50.1% shared the same house with their animals, while 49.9% used separate house for their cattle (Table 3). High proportion of the studied households in Okkicha (77.3%) and Dibbicha (72.3%) shared the same house with animals. On the other hand, 77.3% of the households in Debeke Kebele use separate housing.

About 15.9, 23.5 and 60.6% of households in the study

kebeles were always cleaned barns, sometimes cleaned barns and never practice this, respectively.

Milking and hygienic practices

The study showed that the milking operation is generally conducted in the barn, in at home and an open area. It is also performed two times a day in nearly 85% of the households (Table 4). In general, the udder was not prepared properly (Table 5) and furthermore, in some of the households HH the milker inserts their fingers into the milk to moisten the teat whenever it got dry while milking. The milker does not wash hands pre-milking. Milkers they

Table 2. Educational status and religion of pastoral households (HH's) of six Keble of Abaya District, Borana Pastoral Community.

Parameter	N	%
Education level		
Illiterate	77	58.3
Grade 1-6	45	34.1
> Grade 1-6	10	7.6
Religion		
Protestant	89	67.4
Orthodox Christian	31	23.5
Muslim	3	2.3
Traditional religion (<i>aba kullu</i>) follower's	9	6.8

N=Number of respondents of each Kebele HH.

Table 3. Dairy cattle housing system and barn hygiene of pastoral community of six Keble of Abaya District, Borana Pastoral Community.

Factors/level	Study Kebele {N (%)}						Overall (n=132)
	Gololicha	Debeke	Dibbicha	Ture kejima	Wadye Kejima	Okkicha	
Housing system							
Separate House	12 (54.6)	17(77.3)	6(27.3)	13(59.1)	9(40.9)	5(22.7)	62(49.9)
Mixed with home	10 (45.4)	5(22.7)	16(72.7)	9(40.9)	13(59.1)	17(77.3)	70(50.1)
Barn cleaning							
Clean always	2 (9.1)	1(4.6)	7(31.8)	0	6(27.3)	5(22.7)	21(15.9)
Clean some times	5 (22.7)	4(18.2)	3(13.6)	12(54.6)	7(31.8)	0	31(23.5)
No cleaning	15 (68.2)	17(77.2)	12(54.6)	10(45.4)	9(40.9)	17(77.3)	80(60.6)

N=Number of respondents of each Kebele HH.

dry their hands using their own cloth, and the udder was not properly washed and dried (Table 6). All households do not use towels for cleaning and/or drying the cow's udder. The use of detergents for cleaning of milk equipment was not observed in the majority (77.8%) of pastoral dairy farmers. Most of pastoral households used tap, pond, and river water some times to clean milk equipment, udders and teats of cows, and wet the cow's teats to clean from soil and dirt (Table 7). About 81.5% of the pastoral dairy farmers used unboiled water for cleaning milk handling equipments.

Milk handling equipments and sanitary practices

In the surveyed pastoral area, households were observed using different milk containers for storing and processing milk. About 38.6% of the households mainly used *Cicu* followed by *Okkole* (27.3%) for milk storage. About 11.4% households used plastic jerry cans for milk processing and storage (Table 7, Figure 2). About 69.7% of the respondents washed their milk storage containers

with cold water followed by warm water (12.9%). The other predominant practice (83.33%) washed milk handling equipments using leaves of shrubs of *Makana*, *Ejersaa* and *Dama Kessie*. Washing takes place once a day followed by drying and smoking milk handling equipments with plants stem. About 83.3% of the households smoke milk handling equipments with plants stem such as *Olean Africana* (Ejersa), *Tedecha gara* (*Acacia* spp) and *Balanities aegyptic* (Muka bedana) (Table 7).

DISCUSSION

Characteristics of pastoral dairy households

Land and livestock holding showed a relationship in the study areas where pastoral dairy households with larger landholding had higher livestock holding (Table 1). The majority of households have large area of crop, fallow land and large communal grazing land (Figure 1) which is important for livestock keeping. Livestock holding by the

Table 4. Milking frequency and its operation of six Kebele of Abaya District, Borana Pastoral Community.

Parameter	Study Kebeles {N (%)}						Overall (n=132)
	Gololicha	Debeke	Dibbicha	Ture kejima	Wadye Kejima	Okkicha	
Special place for milking							
Yes	2(9.1)	5(22.7)	1(4.6)	4(18.2)	0	8(36.36)	20(15.2)
Milking place							
In house	7(31.8)	5(22.7)	6(27.3)	9(40.9)	5(22.7)	2(9.1)	34(25.8)
In barn	8(36.4)	7(31.8)	7(31.8)	3(13.6)	10(45.5)	9(40.9)	44(33.3)
On open area	7(31.8)	10(45.5)	9(40.9)	10(45.5)	7(31.8)	11(50.0)	54(40.9)
Frequency of milking per day							
One time	5(22.7)	1(4.6)	0	0	4(18.2)	10(45.5)	20(15.2)
Two times	17(77.3)	21(95.4)	22(100)	22(100)	18(81.8)	12(54.6)	112(84.8)

N=Number of respondents of each Keble HH's.

Table 5. Hygienic practices followed during milking of six Keble of Abaya District, Borana Pastoral Community.

Hygienic practices	Study Kebele {N (%)}						Overall (n=132)
	Gololicha	Debeke	Dibbicha	Ture kejima	Wadye Kejima	Okkicha	
Pre -milking washing teat or udder							
Yes	2(9.1)	0	6(27.3)	0	5(22.7)	2(9.1)	15(11.4)
Teat or udder washing by							
Cold water	9(40.9)	7(31.8)	11(50)	0	0	12(54.6)	39(29.6)
Warm water	3(13.6)	1(4.6)	0	3(13.6)	0	6(27.3)	13(9.9)
No practices	10(45.5)	14(63.6)	11(50)	19(86.4)	22(100)	4(18.1)	80(60.5)
Pre -milking drying teat or udder							
Yes	4(18.2)	5(22.7)	8(36.4)	6(27.3)	0	7(22.7)	30(22.7)
Pre- dipping of teat or udder							
Yes	7(31.8)	4(18.2)	5(22.7)	2(9.1)	6(27.3)	3(13.6)	27(20.5)
Post -dipping of udder or teat							
Yes	2(9.1)	0	3(13.6)	5(22.7)	7(31.8)	4(18.2)	21(15.9)

N=Number of respondents of each Keble households.

respondents is quite high and they keep them for different purposes such as milk, meat and traction. The result shows that most respondents have low level of education (Table 2) which may have an influence on implement improved agricultural practices and good use of agricultural resources in the area. Education is an important entry point for empowerment of the rural communities and also an instrument to sustain development. This could have significant importance in identifying and determining the type of development and extension the service approaches. The role of education is obviously affecting households income, adopting

technologies, demography, health, and as a whole the socio-economic status of the family.

Housing and barn hygiene

The environment in which dairy cows are kept has an effect on their health and welfare. Designing clean, comfortable housing, which is cheaper to maintain, is a key in determining the health and longevity of the dairy cow on the farm. Associations between clean barn and clean udder of cows, an index of environmental sanitation

Table 6. Sanitary practices followed by the milker of six Keble of Abaya District, Borana Pastoral Community.

Hygienic practices	Study Kebele {N (%)}						Overall (n=132)
	Gololicha	Debeke	Dibbicha	Ture kejima	Wadye Kejima	Okkicha	
Before milking hand washing by							
Cold water	4(18.2)	8(36.4)	5(22.7)	0	8(36.4)	9(40.9)	34(25.8)
Warm water	2(9.1)	0	2(9.1)	5(22.7)	2(9.1)	5(22.7)	16(12.1)
No practices	16(72.7)	14(63.6)	15(68.2)	17(77.3)	10(45.5)	8(36.4)	82(62.1)
Hand washing before milking							
Yes	1(4.6)	2(9.1)	8(36.4)	0	4(18.2)	6(27.3)	21(15.9)
Hand drying after wash							
No drying	3(13.6)	7(31.8)	9(40.9)	7(31.8)	0	5(22.7)	31(23.5)
Own cloth	19(86.4)	15(68.2)	13(59.1)	15(68.2)	22(100)	17(77.3)	101(76.5)

N = Number of respondents of each Keble households.

Table 7. Sanitary practices related to milk handling equipments performed in the pastoral community of Abaya District, southern Ethiopia.

Hygienic practices	Study Kebele {N (%)}						Overall (n=132)
	Gololicha	Debeke	Dibbicha	Ture kejima	Wadye Kejima	Okkicha	
Type of water source used							
River water	9(40.9)	5(22.3)	7(31.8)	5(22.3)	8(36.4)	4(18.2)	38(28.8)
Pond water	8(36.4)	4(18.2)	6(27.3)	9(40.9)	3(13.6)	6(27.3)	36(27.3)
Deep well water	1(4.6)	5(22.3)	4(18.2)	-	2(9.1)	-	12(9.1)
Tap water	2(9.1)	6(27.3)	2(9.1)	5(22.3)	7(31.8)	7(31.8)	29(21.9)
Rain water	2(9.1)	2(9.1)	3(13.6)	3(13.6)	2(9.1)	5(22.3)	17(12.9)
Milk storage containers							
<i>Cicu</i> (made from woven grass, small)	5(22.7)	7(31.8)	8(36.4)	12(54.5)	9(40.9)	10(45.5)	51(38.6)
Aluminum cans	1(4.6)	3(13.6)	-	1(4.6)	2(9.1)	-	7(5.3)
<i>Okkole</i> (made from woven grass)	4(18.2)	6(27.3)	10(45.5)	3(13.6)	6(27.3)	7(31.8)	36(27.3)
<i>Gorfa</i> (traditional dairy utensil)	5(22.7)	4(18.2)	3(13.6)	4(18.2)	4(18.2)	3(13.6)	23(17.4)
Plastic cans	7(31.8)	2(9.1)	1(4.6)	2(9.1)	1(4.6)	2(9.1)	15(11.4)
Washing milk storage containers by							
Cold water	12(54.5)	18(81.8)	13(49.1)	18(81.8)	13(49.1)	18(81.2)	92(69.7)
Warm water	4(18.2)	1(4.6)	4(18.2)	1(4.6)	3(13.6)	4(18.2)	17(12.9)
No practices	8(36.4)	3(13.6)	5(22.7)	3(13.6)	4(18.2)	-	23(17.4)
Smoking milk handling equipments							
Yes	16(72.3)	19(86.4)	18(81.8)	19(86.4)	20(90.9)	18(81.8)	110(83.3)
Smoking milk handling equipments by							
<i>Ejersaa</i> (<i>Olea Africana</i>)	15(68.2)	20(90.9)	22(100)	15(68.2)	17(77.3)	14(63.6)	103(78.0)
<i>Makansa</i> (<i>Croton macrostachyus</i>)	1(4.6)	1(4.6)	-	3(13.6)	2(9.1)	5(22.3)	12(9.1)
<i>Muka bedana</i> (<i>Balanities aegyptic</i>)	6(27.3)	1(4.6)	-	4(18.2)	3(13.6)	3(13.6)	17(12.9)

N = Number of respondents of each Keble households.

based on the amount of manure present on the cow and in her environment was a predictor for the occurrence of *coliform mastitis* (Bartlett et al., 1992). The majority of households (Table 3) reported that provision of proper

shelter for animals has not been given the required attention. In almost all studied Kebeles, there was no practice of cleaning of barn rather than daily removal the feces. As a result, teats and udders of cows inevitably



Figure 2. Equipment used for milking, storage and transportation of six Keble of Abaya District, Borana Pastoral Community.

become soiled which lead to contamination of milk during milking (Slaghuis, 1996). Therefore, a proper animal housing system and barn hygiene practices might play a key role for controlling microbial quality and safety of raw cow milk

Milk handling and hygiene

Production of milk and various dairy products takes place under rather unsanitary conditions and poor production practices. At the production level, milking and handling of milk is a concern because personnel as well as milking equipment hygiene are insufficient among the milk handlers (Mogessie, 1990; Zelalem and Faye, 2006). Post harvest losses are associated with poor handling, contamination, low level of technology applied in the

conservation of milk to extend its shelf life and lack of market (Getachew, 2003). In addition to this fact, contamination of milk during milking and handling is high due to the use of unclean equipment and water for washing, personnel not washing hands with soap and potable water (Almaz et al., 2001). Besides, there is lack of proper cleaning of udder, test for abnormalities of milk and lack of cooling facilities. These could lower milk quality and have significant concern on public health (Jayarao and Wang, 1999; Jayarao et al., 2004). Fresh milk is stored in Gorfa, Okkole, Cicu, aluminum cans and plastic jerry-cans (Figure 2) which are smoked for preservation except the equipments made up of plastics, to enhance taste and odour of the product, and to disinfect the vessels, but they are very difficult to clean and to keep clean. As reported by Ashenafi and Beyene (1994), unsmoked containers tend to have high microbial contaminants than the smocked containers. In general, this study revealed that hygiene standards among pastoral dairy households are very poor starting with personal hygiene to equipment used for milking, storage and transportation. Equipment used for milking, storage and transport include mainly traditional gourds, plastic jerry-cans and in few numbers aluminum cans. Traditional Gourds, which are usually smoked after usage, pass hygiene standards however; the milk is often transferred to plastic jerry cans and contributes to milk spoilage as they are difficult to clean (Gilmour, 1999; Bekele and Molla, 2000).

Conclusions

This study found that the majority of the pastoral households used traditional dairy containers. The predominant practice was washing milk handling equipments by the use of water and leaves of shrubs. The high incidence of dairy animals diseases, unhygienic conditions of milking and storage processes, transferring of milk into different containers, use of insufficiently cleaned milk equipment and the use of unclean water are basic determinants of milk quality and the hygienic practices followed by the milk producing households in the pastoral community. These results appear to suggest the need for improved hygienic practice of milk production.

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Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

- Ashenafi M, Beyene F (1994). Microbial load, microflora, and keeping quality of raw and pasteurized milk from a dairy Farm. *Bull. Anim. Health Prod. Afr.* 42:55-59.
- Almaz G, Howard AF, Wilhelm HH (2001). Field survey and literature review on traditional fermented milk products of Ethiopia. *Int. J. Food Microbiol.* 68:173-186. [http://dx.doi.org/10.1016/S0168-1605\(01\)00492-5](http://dx.doi.org/10.1016/S0168-1605(01)00492-5)
- Bartlett PC, Miller GY, Lanc SE, Heider LE (1992). Managerial determinants of intramammary coliform and environmental streptococci infections in Ohio dairy herds. *J. Dairy Sci.* 75:1241-1252. [http://dx.doi.org/10.3168/jds.S0022-0302\(92\)77873-4](http://dx.doi.org/10.3168/jds.S0022-0302(92)77873-4)
- Bekele G, Molla B (2000). Bacteriological quality of raw cow's milk from four dairy farms and a milk collection center in and around Addis Ababa. *Berliner and Mucnchener Tieraerztliche Wochenschrift.* 113:276-278.
- Coppock DL (1994). The Borana plateau of southern Ethiopia: Synthesis of Pastoral Research Development and change, 1980-1991. ILRI, Addis Ababa, Ethiopia. pp. 15-33.
- CSA (2013). Federal Democratic Republic of Ethiopia Central statically Agency, Ethiopia.
- FAO (2005). Food and Agriculture Organization and World Food Program; FAO Global Information and Early Warning System on food and Agriculture. Special Report of FAO/WFP Crop and food supply assessment mission to Ethiopia. pp. 1-10.
- FEWS NET/USAID (2004). Famine Early Warning System Network: Food Security. Trends for pastoralists in Greater Horn of Africa. *Food Secur. Bull.* pp. 1-5.
- Getachew F (2003). Milk and dairy products, post-harvest losses and food safety in sub-Saharan Africa and the Near East. Assessments report on the dairy sub sector in Ethiopia. Action Programme for the Prevention of Food Losses, FAO, Rome, Italy.
- Gilmour D (1999). Milking. In: Smallholder dairying in the tropics. ed. Falvey L. and Chantalakhana C. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 289-298.
- Jayarao BM, Pillai SR, Sawant AA, Wolfgang DR, Hegde NV (2004). Guidelines for monitoring bulk tank milk somatic cell and bacterial counts. *J. Dairy Sci.* 87:3561-3573. [http://dx.doi.org/10.3168/jds.S0022-0302\(04\)73493-1](http://dx.doi.org/10.3168/jds.S0022-0302(04)73493-1)
- Jayarao BM, Wang L (1999). A study on the prevalence of gram-negative bacteria in bulk tank milk. *J. Dairy Sci.* 82:2620-2624. [http://dx.doi.org/10.3168/jds.S0022-0302\(99\)75518-9](http://dx.doi.org/10.3168/jds.S0022-0302(99)75518-9)
- Mogessie A (1990). Microbiological quality of Ayib, a traditional Ethiopian cottage cheese. *Int. J. Microbiol.* 10:263-268. [http://dx.doi.org/10.1016/0168-1605\(90\)90074-F](http://dx.doi.org/10.1016/0168-1605(90)90074-F)
- Slaghuis B (1996). Sources and significance of contaminants on different levels of raw milk production. In: symposium on bacteriological quality of raw milk. international dairy federation proceedings, Brussels, 13-15, March, 1996.
- Solomon D (1999). Diversification of livestock assets for risk management in the Borana pastoral system of Southern Ethiopia, PhD thesis, Utah State University, Logan, Utah. pp. 10-31.
- SPSS (Statistical Procedures for Social Sciences) (2007). SPSS (Version 16). Statistical. SPSS BI Survey Tips. Inc. Chicago, USA.
- Zelalem Y, Faye B (2006). Handling and microbial load of cow's milk and irgo-fermented milk collected from different shops and producers in central highlands of Ethiopia. *Ethiopia J. Anim. Prod.* 6(2):67-82.