G.J.A.S.R

GLOBAL JOURNAL OF ANIMAL SCIENTIFIC RESEARCH

Journal homepage: www.gjasr.com

Print ISSN:2345-4377 *Online ISSN:2345-4385*

Review Article

Microbial safety, physical properties and chemical composition of cow milk in Ethiopia, A Review

Addisu Tegegn

Oromia Agricultural Research Institute, Food Science Research Directorate, Food Microbiology Research Team, Ethiopia

ABSTRACT

Ethiopia takes first place in the cattle herd population from Africa. However, the production and productivity and quality of milk are low due to various factors such as genetic makeup of the breeds, inadequate and poor quality feed and water resources, and lack of knowledge for appropriate hygienic practices in milk production. Cow milk is recognized as complete human food as it constitutes principal nutritionally important components such as water (87.2%), protein (3.5%), fat (3.7%), milk sugar or lactose (4.9%), ash (0.7%), and dry matter (12.8%). This, on the other hand, makes milk a suitable medium for the growth and multiplication of a variety of pathogenic and spoilage microflora. Research reports of microbial and physicochemical qualities of cow milk published in different Journals have been reviewed in this paper. Studies show that a total bacterial load range of 4.57 and 9.82 log CFU ml^{-1} has been reported in Hawassa City and Gurage Zone in Southern Ethiopia, respectively as a minimum and maximum values. Whereas, a total coliform count of 6.19 log CFU ml^{-1} was reported in Yabello, Borena Zone as maximum contamination. The minimum value was recorded in Gurage Zone being 4.03 log CFU ml^{-1}. Yeast and mold contamination was also widely studied and reports showed that the highest load of 7.24 log CFU ml^{-1} was recorded in Abuna Gindeberet District of West Showa Zone. A count as low as 0.622 log CFU ml^{-1} was reported in the Dawa Chefa District of Amhara Region. As major chemical constituents of cow milk, fat (4.19-6.02 %), protein (3.20-3.98 %),

Corresponding Author: Addisu Tegegn < addisutegegn16@gmail.com >

Cite this Article: Tegegn, A. (2021). E Microbial safety, physical properties and chemical composition of cow milk in Ethiopia, A Review. *Global Journal of Animal Scientific Research,* 9(1), 51-75.
Retrieved from http://www.gjasr.com/index.php/GJASR/article/view/71

Article History: Received: 2021.02.04 Accepted: 2021.03.12

lactose (3.79-5.39 %), SNF (7.60-9.77 %), ash (0.68-0.80 %), total solids (12.02-15.47 %) and a titratable acidity (0.16-0.38 %) were reported in different parts of the country. Moreover, physical parameters of pH and specific gravity ranges of 6.30-6.48 and 1.022-1.06 gm/cm^3 were recorded from milk samples studied in parts of Ethiopia. From most of the studies, it could be observed that most of the milk samples are of substandard quality in terms of microbial load according to standards set by different Organizations rendering them unsafe and hazardous for raw consumption and unsuitable for further processing. This indicates the high prevalence of inadequate hygienic practices among the dairy producers which in turn necessitates the delivery of training on the general pre and post-production management of cow milk.
Keywords: Cow milk, microbial safety, chemical composition, physical properties

INTRODUCTION

Milk is an important part of the human diet with essential nutritional constituents such as water (87.2%), protein (3.5%), fat (3.7%), milk sugar or lactose (4.9%), ash (0.7%), and dry matter (12.8%) (Byron *et al*., 1974; Melese and Tesfaye, 2015) and thus recognized as complete human diet. Cow milk is long accepted as a highly nutritious and valuable human food (Ali, 2010) and an economically important farm commodity and investment option for smallholder farmers in developing countries like Ethiopia (Haile *et al*., 2012).

Ethiopia is thought to have the largest livestock population in Africa with a total estimated herd of cattle of 53.4 million (CSA, 2011). Reports show that despite the huge cattle population and favorable climatic conditions and resources, per capita consumption in the country is 19 kg/year which is extremely minimal as compared to a global average of 100 kg/year. It too is far below that of Africa (27 kg/year). Furthermore, Ethiopia's milk consumption status is much lower than that recommended by World Health Organization (WHO) and FAO of 200 liters and 62.5 kg per annum, respectively (FAO, 2006). This may be attributed to the low current production of milk in the country. Among the various factors determining productivity and quality of milk in Ethiopia are genetic makeup of the breeds, inadequate and poor quality of feed resources, prohibitive price of crossbred heifers, and high incidence of animal diseases (Fekadu, 1994).

The magnitude of microbial load in milk is one of the critical parameters to be considered in judging the degree of its quality. The presence of higher microbial load produces an undesirable effect on the quality and safety of milk and its products and results in its unsuitability for human consumption and further processing (Nanu *et al*., 2007). Due to its high water content, nearly neutral pH, and presence of several vital nutrients, it provides a suitable environment for the growth and proliferation of an array of microorganisms including pathogenic species (Ruegg, 2003).

Contamination of milk by microbes might arise from unsanitary conditions of milking, inadequate cleanliness of milking utensils, poor hygiene of milking individuals, teats and udders of cows which became soiled when laying in muddy stalls (faces direct contact with ground, dung, urine, and feed refusals while resting) (Abebe *et al*., 2012) and repeated use of the same bedding material which is proved to harbor large number of microorganisms (Murphy and Boor, 2000). In general microbial quality of cow milk has a critical food safety implication for human consumption and product processing. Therefore, this review has aimed to investigate the status of the microbial and physicochemical qualities of cow milk in Ethiopia across different regions.

MICROBIAL LOAD

Total bacterial/ total aerobic mesophilic bacteria / total viable count

Total bacterial count which is synonymously used with total aerobic mesophilic bacterial count or total viable count is a key indicator for monitoring the hygienic condition practiced at the pre, during, and post-production and handling of food including raw milk (Chambers, 2002) with an important implication of public health hazard. Most of the reports in Ethiopia showed that the majority of the cow milk samples investigated for microbial quality exhibited a high total bacterial count that exceeded the maximum acceptable standard of 6.3 logs CFU/ml set by EAS (2007) and the European Union (Fig. 1). Table 1 describes the total bacterial count in cow milk samples from studies reported by some authors in different parts of the country in nearly the last two decades. In Eastern Ethiopia (parts of Hararghe), Hawaz *et al.* (2015) studied the microbial quality of raw cow milk and the analysis showed a total bacterial count average of 6.25±0.87 (range: 5.77 to 6.64) in Haramaya, Kerssa, Babile, and Kulubi Districts (Table 1). Compared to the American and European community member state's bacteriological standards of dairy products ($2x10^5$ - $4x10^5$ CFU/ml and 150 CFU/mL, respectively (Heeschen, 1997)), the milk samples were categorized as of poor quality. Similarly, Abebe *et al.* (2012) assessed the variability in microbial quality among the different agro-ecologies of Gurage Zone in Southern Nations and Nationalities and Peoples Region (SNNPR). The researchers reported an average Aerobic Mesophilic Bacterial Count (AMBC) of 9.82 log CFU/mL. As a conclusion, they stated that the overall AMBC of the milk samples was higher than the maximum acceptable limits given for raw milk intended for processing (1.0×10^5 CFU/mL) and direct human consumption (5.0×10^4 CFU/mL) (Bodman and Rice, 1996). Solomon *et al.* (2015) had a study comparing the microbial quality of cow milk samples collected from three sources, *viz.,* Hotels, cooperatives, and farmers in Dawa Chefa District of Amhara Region, Ethiopia. Even though no significant statistical difference existed between the milk samples from the three sources, samples from the hotel were the poorest in quality reading mean log value of 7.54 log10 CFU/mL. The overall mean of total bacterial count (7.25 log10 CFU/mL) (Table 1) was compared against the standard set by the American Public Health Association (1992) which is 2 $\times 10^5$ - 4×10^5 CFU/mL and classified as of unacceptable quality. In a similar study conducted in Bench Maji Zone (Mizan Aman, Debub Bench, and Shei Bench Districts) of SouthWestern Ethiopia, samples have become significantly different ($p<0.05$) in total bacterial count (Teshome and Tsfaye, 2016) with a range of 6.817±0.381 to 7.235±0.277 and overall mean of 7.091±0.342 log10 CFU/mL (Table 1). In addition to Zones from the Regional States in Ethiopia, many studies have been done on the microbial qualities of cow milk in selected sub-cities of Addis Ababa. Biruktawit (2016) and Fufa *et al*., (2019) found an overall total bacterial count mean of 8.6 ± 1.01 and 7.17 ±0.42 log10 CFU/mL, respectively. Moreover, it was concluded by Abebe *et al*., (2012) that there was no significant difference in TBC between samples from different agro-ecologies in Gurage Zone, Southern Ethiopia. However, the herd size group and season had influenced the bacterial population differently (Tadele *et al.,* 2016). Comparable results of 7.57, 7.52 and 8.18 log10 CFU/mL have been recorded from the study conducted in Kenya by Wanjala *et al*., (2017) and slightly lower counts (6.10±0.03, 6.00±0.01, 5.97±0.01, 6.12±0.03 and 6.21±0.04 (log CFU/mL)) were reported in five different sites in India (Nalwaya *et al*., 2018).

Total coliform count

Most of the cow milk microbial quality studies in the Country have included analysis of coliforms as principal indicators of contamination with pathogenic species. Most of the studies have reported comparable values of total coliform counts in different parts of Ethiopia. In Ezha District of Gurage and Wolayita Zones in the Southern part of the country, with the significant difference among different agro-ecologies, an overall mean total coliform count of 4.03 (Abebe *et al*., 2012) and 4.84 log10 CFU/mL (Rahel, 2008), respectively, were reported (Table 1). A relatively higher coliform population was obtained in samples collected from three Districts, i.e. Mizan Aman (5.203±0.230), Debub Bench (5.187±0.211), and Shei Bench (4.911±0.324) (overall mean: 5.100±0.288) of Bench Maji Zone in South-Western Ethiopia, (Teshome and Tesfaye, 2016) (Table 1). Tadele *et al*., (2016) revealed that total coliform count in milk was affected by seasons (rainy and dry). Counts were significantly higher during long and short rainy seasons compared to that obtained during the dry season (3.76±0.14) with the overall mean counts being 4.23±0.12 log10 CFU/mL. Coliform count (5.47 log10 CFU/mL) reported by Solomon *et al.,* (2015) in Dawa Chefa District of Amhara Region (Table 1), was comparable to that of Biruktawit (2016) in Addis Ababa, with an overall mean log value of 6.15±0.92. Besides seasonal variability in the coliform population, breed types have also shown an influence on the count in milk samples. Asaminew and Eyasu (2010) reported that there was a slight difference in total coliform count between local cows (4.52±0.15) and crossbreeds (4.45±0.15) in Bahir Dar area and Mecha District of Amhara Region. It was also seen to vary between samples from individual farmers (4.41±0.16) and dairy cooperatives with the higher value being recorded from the later source (4.94±0.23) (Table 1). A study conducted along a dairy value chain in selected sub-cities of Addis Ababa revealed that a significantly higher coliform count was reported in milk sampled from dairy farms (5.91±0.17) as compared to those from vendors (5.77±0.19) and restaurants (2.17±0.13) (overall mean 4.85±0.28 log10 CFU/mL) (Fufa *et al.*, 2019). Likewise, the coliform count was made on milk samples following the dairy value chain (producers, collectors, retailers) in four Districts of Harar milk shed in Eastern Ethiopia. Establishing a similar pattern, the study made it clear that, even though no statistically significant variability existed between the different actors, a higher mean log value of 6.35±0.87 was recorded in samples from producers followed by collectors (6.29±0.81) and retailers (6.09±0.94). This higher coliform count scenario at the production level and declining trend at the advanced stage in the value chain line may be from the fact that milk is kept at refrigeration temperature by restaurants, vendors, and collectors until sold. The almost equivalent value of the total coliforms (6.15 ± 0.92 log10 CFU/mL) (overall mean: 5.45±0.80 log10 CFU/mL) was reported by Hawaz *et al.* (2016) in samples collected from Harar, Eastern Ethiopia (Table 1). Except few of the results, most of the milk samples tested were inferior in standard from coliform count point of view according to the East African Standards (EAS 67:2007) (4.7 log10 CFU/mL) and the European Union Standards (2.0 log10 CFU/mL) (Fig. 2).

Yeast and mold

Yeast and mold contamination of food products including milk plays an important role in spoilage and shortened shelf life (Gamal *et al.*, 2015). Samples collected from Hotels, farmers and cooperatives were analyzed for yeast and mold contamination and a mean log10 CFU/mL values of 0.74 ± 0.03, 0.46 ± 0.035, and 0.62 ± 0.09 (overall mean: 0.622), respectively, were reported by Solomon *et al.,* (2015) in Dawa Chefa District of Ahmara Region (Table 1). On the contrary, significantly higher yeast and mold count was recorded in three Districts of Bench-Maji Zone in South-Western Ethiopia with the count ranging from 3.762±0.468 to 4.001±0.588 log10 CFU/mL (overall mean: 3.902±0.477 log10 CFU/mL) (Teshome and Tesfaye, 2016) (Table 1). Tadele *et al.*, (2016) studied cow milk quality (collected from udder) in terms of yeast and mold count from the production system, herd size, and season point of view across the milk supply chain in Eastern Ethiopia. A relatively higher yeast count (overall mean: 2.57±0.10 log10 CFU/mL) was recorded in samples from pastoral community (2.57±0.11 log10 CFU/mL), medium-sized heard (2.70±0.11 log10 CFU/mL) and short rainy season (2.75±0.14 log10 CFU/mL). Similarly, a higher mold count (2.72±0.12 log10 CFU/mL) (overall mean: 2.67±0.10 log10 CFU/mL) was detected in milk samples from pastoral communities in the same study. Milk samples collected during the long rainy season had a higher mold count of 2.78±0.15 log10 CFU/mL whereas, medium-sized herds gave the greater count of 2.78 ±0.21 log10 CFU/mL (Table 1). Most of the milk samples collected across the country had shown an unacceptable level of yeast and mold count which is set to be below 2.1 log10 CFU/mL (Torkar and Vengust, 2008) (Fig. 3) indicating a high post-production unhygienic practice. Contrary to the situations in Ethiopia, there are cases where all the cow's milk samples were entirely free of yeast and mold contamination in India (Nalwaya *et al*., 2018).

Physicochemical properties

Physicochemical qualities are meant to determine the nutritive values and consumer acceptability of milk (O'Connor 1993). Almost the majority of the previous research reports have included the studies of physical properties and chemical constituents of cow milk besides the microbial quality so far in Ethiopia. Among the important physicochemical parameters are fat, protein, lactose, total salts, Solids-not-fat (SNF), added water, density, and freezing point.

Fat content

Fat is the main source of energy in milk and is the most valuable constituent which is present in the form of an emulsion of fat cells suspended in the milk. It has a nutritional role by energy intake; 9 kcal/g as dietary lipids (Florence, 2010). Fat is one of the chemical constituents of milk that determines its quality. So far, some researchers have reported the level of the fat content of cow milk as one of the principal chemical components in different parts of Ethiopia. The study of Tadesse *et al*., (2020) revealed that the fat content of cow milk was significantly varying between highland (4.40±0.79%), midland (3.78±0.60%), and lowland (4.46±0.50%) agro-ecologies in Abuna District in West Showa Zone, Ethiopia, with the highest fat content recorded at lowland areas. Almost equivalent fat content (4.38±0.06%) was reported by Belay and Janssens (2014) and Teshome *et al*., (2015) (4.28±0.05%) in samples collected from smallholder dairy farms in Jimma (South-Western Ethiopia) and, Shashemene (Southern Ethiopia) Towns, respectively. Hawaz *et al*., (2015) studied milk samples from four Districts in Eastern Ethiopia and reported an overall mean fat content of 5.12±0.84 % which is a little higher than the aforementioned figures. In a study comparing the physicochemical qualities of milk from the cow, camel, and goat, Legesse *et al*. (2017) reported that cow milk had an overall fat content (5.54 ± 0.65 %) slightly lower than that of goat (6.79 ± 0.38 %) but superior to that of camel (3.93 ± 0.15 %) (Table 2).

Table 1:. The overall mean of Total Bacterial, coliform, yeast, and mold counts in cow's milk samples in different parts of Ethiopia

Total bacterial count (log10CFU/ml±SE)	Study area	Reference	Total coliform count (log10CFU/ml±SE)	Study area	Reference	Yeast and mold count (log10CFU/ml ±SE)	Study area	Reference
7.87	Bila Sayo, East Wollega, Oromia Region	Alganesh, 2002	5.86±0.12	Oromia Region Eastern Ethiopia	Tadele *et al.* (2016)	0.622	Dawa Chefa District of Ahmara Region	Solomon *et al.* (2015)
7.30	Guto Wayu District, East Wollega Zone	Alganesh, 2002	4.45	Bahir Dar Surrounding and Mecha District, Amhara Region	Asaminew and Eyasu (2011)	3.902±0.477	Bench-Maji Zone South-Western Ethiopia	Teshome and Tesfaye (2016)
7.58±0.09	Bahir Dar Surrounding and Mecha District, Amhara Region	Asaminew and Eyasu, 2011	6.19 ± 0.03	Yabello, Southern Ethiopia	Gurmessa (2015)	2.57±0.10*	Eastern Ethiopia	Tadele *et al.*, (2016)
9.82+0.81	Gurage Zone, Southern Ethiopia	Abebe *et al.*, 2012	4.48	Milk shed in Bahir Dar, Amhara Region	Deresse (2008)	2.67±0.10**	Eastern Ethiopia	Tadele *et al.*, (2016)
6.88±0.04	Borena Pastoral community, Oromia Region	Tollossa *et al.*, 2012	4.85±0.28	Selected Sub Cities of Addis Ababa	Fufa *et al.* (2019)	7.24±0.21	Abuna Gindeberet District, West Showa Zone	Tadesse *et al.*, 2020
4.57±0.21	Hawasa City, SNNP Region	Haile *et al.*, 2012	4.03+0.09	Gurage Zone, Southern Ethiopia	Abebe *et al.* (2012)	7.21 ± 0.21		Korma *et al.* (2018)

6.25±0.87	Harar milk shed, Eastern Ethiopia	Hawaz *et al.*, 2015	6.25±0.87	Wolayita, SNNPR	Rahel (2008)	4.266 ± 0.032	Hawasa City, SNNPR	Debela *et al.* (2015)
7.25	Dawa Chefa District, Amhara Region	Solomon *et al.*, 2015	5.100±0.288	South Western Ethiopia (SNNPR)	Teshome and Tesfaye (2016)			
6.02± 0.14	Oromia Region Eastern Ethiopia	Tadele *et al.*, 2016	4.23±0.12	Eastern Ethiopia	Tadele *et al.* (2016)			
7.09±0.342	Bench Maji-Zone, Southwestern Ethiopia	Teshome and Tesfaye, 2016	5.47	Dawa Chefa District of Amhara Region	Solomon *et al.* (2015)			
8.6 ± 1.01	Selected Sub Cities of Addis Ababa	Biruktawit, 2016	4.52±0.15	Bahir Dar area and Mecha District of Amhara Region	Asaminew and Eyasu (2010)			
7.17±0.42	Selected Sub Cities of Addis Ababa	Fufa *et al.*, 2019	4.85±0.28	Selected Sub-Cities of Addis Ababa	Fufa *et al.*, 2019			
8.13±0.31	Abuna Gindeberet, West Showa	Tadesse *et al.*, 2020	5.45±0.80	Harar, Eastern Ethiopia	Hawaz *et al.*, 2015			
			5.99±0.35	Abuna Gindeberet, West Showa	Tadesse *et al.*, 2020			

*Yeast count; **mold count

Samples collected from three Districts of Bench Maji Zone were reported to have an overall mean fat content of 6.024±0.763 (Teshome and Tesfaye, 2016). Biruktawit (2016) also reported a fat content ranging from 4.27 ± 1.00 to 4.58 ± 1.15 (mean: 4.42±1.16) in milk samples collected from different milk producers in selected Sub-Cities of Addis Ababa. On the other hand, the report from far southern Ethiopia, Yabello, Borena Zone, recoded significantly higher fat level of 6.09±0.09 % (mean: 6.01±0.09) in cow milk (Gurmessa *et al.*, 2015). Variability in fat content among milk samples may be attributed to factors such as breed, feed type, parity, and stage of lactation. Generally, a fat content of the milk samples studied across the country is above the acceptable range of 3.25 %, 4.5%, and 3.5% set by East African Standard (EAS 67:2000), Ethiopian Quality Standards Authority (EQSA, 2009), respectively (Fig. 4A).

Protein content

Milk protein is one of the important quality determinants widely studied in Ethiopia. Hawaz *et al.,* (2015) reported a protein content of 4.31±0.41, 3.12±0.29, 3.19±0.31 and 3.42±0.60 % (overall mean: 3.51±0.63) in the Districts of Babile, Haramaya, Karsa, and Kulubi (Eastern Hararghe, Ethiopia), respectively, which showed a highly significant difference among the different sites. Similarly, Teshome and Tesfaye (2016) recorded a protein content (overall mean: 3.980±0.414) in milk samples collected from three Districts (Mizan Aman, Debub Bench, and Shei Bench) in Bench-Maji Zone, Ethiopia. Among the three Districts, the highest percentage of protein was obtained from Shei Bench (4.140±0.320) which is followed by Debub Bench (3.954±0.402) and Mizan Aman (3.844±0.475). Likewise, Gurmessa *et al.* (2015) reported an almost equivalent protein content in milk samples obtained from open market and household milk producers with an overall mean percentage of 3.94+0.07 (Table 2). In an analysis of protein content in milk samples collected from dairy cooperatives, hotels, shops, and small-scale milk producers in Shashemene Town, a range of 3.42±0.00 to 3.45±0.00 was recorded (Teshome *et al.*, 2015). In Selected sub-Cities of Addis Ababa however, a seemingly lower overall mean protein content of 3.2 ± 0.33 % was recorded in milk samples collected from different sources (Biruktawit, 2016) (Table 2). Milk samples from smallholder dairy farms in Jimma Town have exhibited an overall mean protein content of 3.21±0.06 which is comparable to that reported in Addis Ababa (Belay and Janssens, 2014) (Table 2). In a comparative study of the physicochemical qualities of cow, camel, and goat milk in Somali Regional State, cow's milk took second place (3.54 ± 0.12 %) following that of goat's (4.62 ±0.56 %) (Legesse *et al.*, 2017 %) based on an overall mean value. The normal range of protein in cow milk is 2.9 - 5.0 % (O'Connor, 1994). Thus it could be shown that the protein content in cow milk in Ethiopia lies in the acceptable range. According to the recommendation of the European Union quality standards for unprocessed whole milk total protein content should not be less than 2.9 % (Tamime, 2009) and 3.2% (EQSA, 2009) (Fig. 4B).

Lactose content

Lactose is the main carbohydrate of milk, similar to the previous parameters, is an important chemical property determining the chemical quality of milk. In Harar milk shed, Eastern Ethiopia, milk samples collected from four Districts have been analyzed and a lactose content range of 3.54±0.63to 4.30±0.63 % was reported (Hawaz *et al*., 2015). Gurmessa *et al*. (2015) obtained a higher lactose content (4.53±0.16 – 4.91±0.18 %) in milk samples collected from open market and household producers in Yabello District of Borena Zone. Results obtained from milk samples from Shashemene Town were comparable to that of samples from Yabello District. It was reported in a range of 4.26±0.00 to 4.69±0.00 % in this study. Additionally, in the South-Western part of the country, Jimma Town, almost the same magnitude of lactose (4.34±0.13 %) was recorded (Belay and Janssens, 2014). In a similar study done in Abuna Gindeberet District of Western Showa Zone, an elevated percentage of lactose was reported in milk samples collected from highland, midland, and lowland agro-ecologies. The highest lactose percentage of 5.64±0.05 was recorded in samples from the lowland agroecology followed by highland (5.51±0.27) and midland (5.09±0.20) (Tadesse *et al*., 2020). European Union had set a standard for lactose content in unprocessed whole milk to be 4.2 % (Tammime, 2009) with most of the milk resources in Ethiopia lying in the high-quality category (Fig. 4C).

Solid-not-fat (SNF) content

Cow milk samples collected from different sources in some Sub-Cities of Addis Ababa had exhibited an SNF range of 7.43 ± 1.67 to 7.72 ± 0.45 % (Biruktawit, 2016). However, Hawaz *et al*. (2015) reported a slightly higher level ranging from 7.81 ± 0.68 to 8.18±1.47 %. In Shashemene Town, (Southern Ethiopia), samples collected from dairy cooperative milk collectors had the highest SNF percentage (8.90±0.00 %) followed by Hotels (8.63±0.12 %), Kiosk (8.43±0.03 %), and small scale milk producers (8.40±0.00 %) (Teshome *et al*., 2015). A higher magnitude of SNF (9.11 ± 0.19 to 9.81 ± 0.15 %) was obtained in samples collected from Yabello District, Borena Zone (Gurmessa *et al*., 2015). At Abuna Gindeberet District, however, SNF values superior to those previously mentioned have been recorded. The study showed that 10.14±0.45, 9.99±0.47, and 9.25±0.35 % were reported from samples collected from Highland, lowland, and midland areas, respectively, of the District (Tadesse *et al*., 2020). Samples collected from Addis Ababa and East Hararghe Zone didn’t qualify in terms of SNF content as compared to EUS and FAO (2009) standards with West Showa Zone taking first place in SNF content (Fig. 4D).

Total Solids (TS)

Cow milk compared to that of camel and goat was reported to bear the highest percentage of total solids. Mean value of 14.60 ± 0.60 for cow milk followed by 14.25 ± 1.16 for goat and 13.65 ± 1.40 in camel milk (Legesse *et al*., 2017) were reported. Gemechu *et al*. (2015) reported that an overall mean percentage of total solids of 12.87±0.11 was obtained from milk samples collected from different sources in Shashemene Town. Whereas total solids with a higher mean overall value of 15.47±0.15 (range: 14.93±0.14 to 16.01±0.14%) was reported by Gurmessa *et al*. (2015) in Yabello District of Borena Zone. Similarly, in samples collected from Harar milk shed, 13.10±1.28 % total solids) were recorded by Hawaz *et al*. (2015). European Union recommends that total solids in cow milk shouldn't be less than 12.5% and thus, the majority of the milk samples investigated in Ethiopia are proved to be of an acceptable standard.

Titratable Acidity

The acid content of milk is a rough indication of its age and the manner with which it was handled. Moreover, it may also be attributed to bacterial growth and multiplication during transportation and long storage before selling (Gurmessa, *et al*., 2015). Cow milk is said to be normal if it contains an apparent acidity ranging from 0.14 to 0.16 % as lactic acid (O'Connor, 1995). Milk samples collected from open market and household producers showed a titratable acidity range of 0.17±0.003 - 0.22±0.005 % (Gurmessa, *et al*., 2015) in Yabello District of Borena Zone. Additionally, an overall titratable acidity means of 0.25±0.05 and 0.190±0.023 was reported in Harar milk shed areas and Bench Maji Zone, respectively (Hawaz *et al*., 2015; Teshome and Tesfaye, 2016). It was observed that higher microbial load had contributed to increased titratable acidity around Haramaya, Ethiopia. In Bahir Dar Zuria District, in milk samples from individual farmers and dairy cooperatives, an acidity of 0.23 ± 0.01 and 0.28 ± 0.01 % was reported (Asaminew and Eyassu, 2011). From the fact that almost all the studied milk samples had a titratable acidity percentage above the normal value, it could be suggested that lactic acid development had set in. This may be due to a lack of appropriate hygienic practices during milking and post milking handling.

Ash Content

At Yabello District of Borena Zone, an overall mean ash content of 0.80+ 0.015 was reported (Gurmessa, *et al*., 2015). Milk samples collected from three Districts in Bench Maji Zone were studied showing an overall mean ash percentage of 0.795±0.056 (Teshome and Tesfaye, 2016). Similarly, mean ash content of 0.75 ± 0.07, 0.74±0.00 and 0.68±0.16 in Somali Region, Shashemene Town, and Harar milk shed areas, respectively (Legesse, 2017; Teshome *et al*., 2015; Hawaz *et al*., 2015).

Specific Gravity

Specific gravity is one of the important physical parameters that determine the quality of milk. A higher value of specific gravity (1.035 gm/cm^3) is an indicator for skimming off of fat whereas a lower value (1.020) shows the addition of water (O'Connor, 1993). The addition of water tends to decrease the specific gravity of milk, while the addition of cream, removal of fat, and reduction of temperature increase the value (O'Connor, 1995). Normal milk should exhibit a specific gravity range of 1.027 – 1.035 gm/cm^3 (Tamime, 2009). An overall mean specific gravity of 1.06 ±0.03 gm/cm^3 was recorded in Somali Region which is above the normal range (Legesse *et al.*, 2017). In Shashemene Town, a mean overall specific gravity of 1.030±0.000 gm/cm^3 was recorded from samples collected from different sources. Moreover, samples collected from open market and household producers had a specific gravity range of 1.013±0.001 - 1.031±0.001 gm/cm^3 in Yabello District of Borena Zone (Gurmessa *et al.*, 2015). A similar result (1.0325±0.0017 gm/cm^3) was recorded in Abuna Gindeberet District of West Showa Zone in samples collected from representative agro-ecologies; highland, midland, and lowland with the non-significant statistical difference between the three (Tadesse *et al.*, 2020). Most of the reviewed findings seem to fulfill the specific gravity value set by FAO (1988) ranging from 1.02 – 1.033 gm/cm^3.

PH Value

The pH of cow milk is a good signal for the hygienic status of milk. At 20 ^oC the pH of milk usually ranges between ≤ 6.6 to ≥ 6.8 **(**Walstra *et al.,* 1999**).** Most of the cow milk samples studied showed a pH value below the normal range mentioned earlier. In Somali Region, a mean pH value of 6.30±0.15 was reported by Legesse *et al*. (2017). An equivalent value (6.32±0.07) of pH was recorded in samples collected from different sources in Shashemene Town (Teshome *et al*., 2015). Samples collected from Yabello District showed a similar value of pH of 6.39+ 0.035 (Gurmessa *et al*., 2015). A little bit higher pH (6.477±0.273) was reported in samples collected from three Districts of Bench-Maji Zone of Southern Ethiopia (Teshome and Tesfaye, 2016). In Abuna Gindeberet District of Western Showa Zone too, comparable values of mean pH of 6.47±0.42 was recorded in milk samples collected from different Ago-ecologies (Tadesse *et al*., 2020). Most of the cow milk samples investigated in Ethiopia have shown a pH lower than the minimum set value of 6.6 to 6.8 which indicates the higher prevalence of bacterial growth and multiplication.

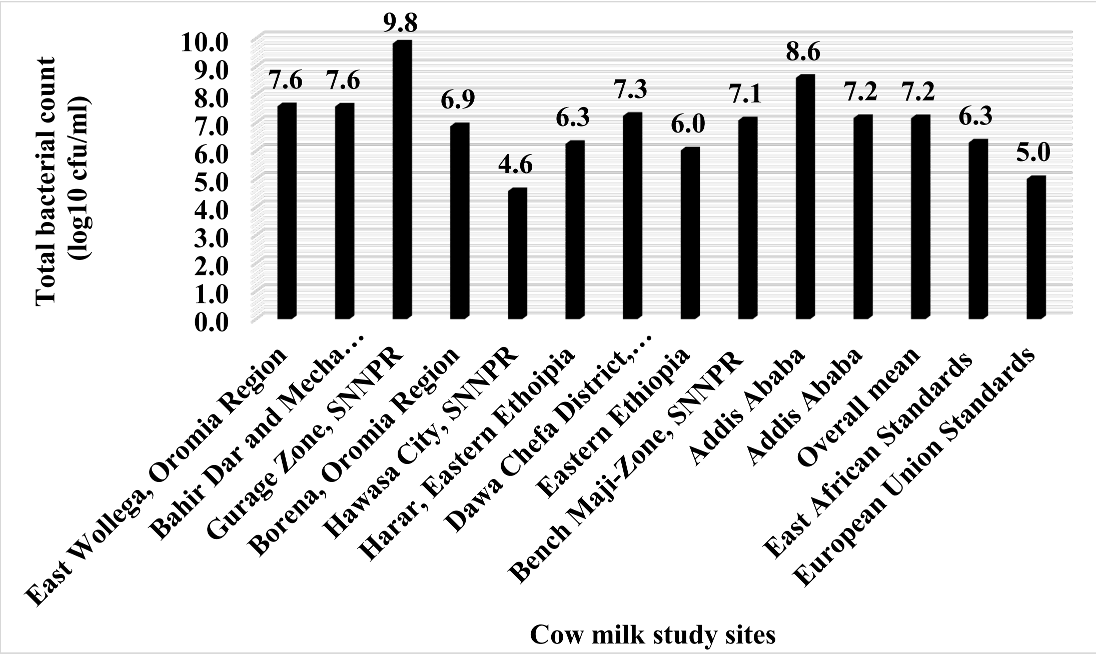


Figure 1: Comparison of Total Bacterial Count in cow milk samples in Ethiopia against East African and European Union Standards

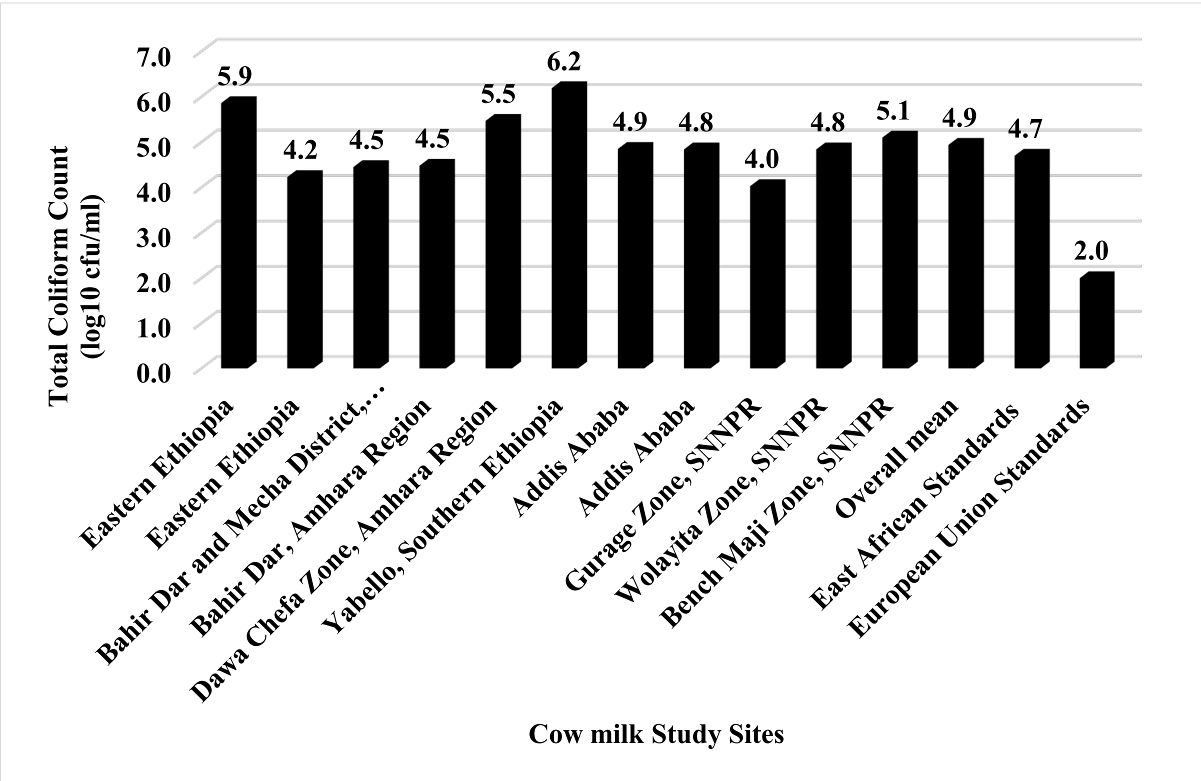


Figure 2: Comparison of Total Coliform Count in cow milk samples in Ethiopia against East African and European Union Standards

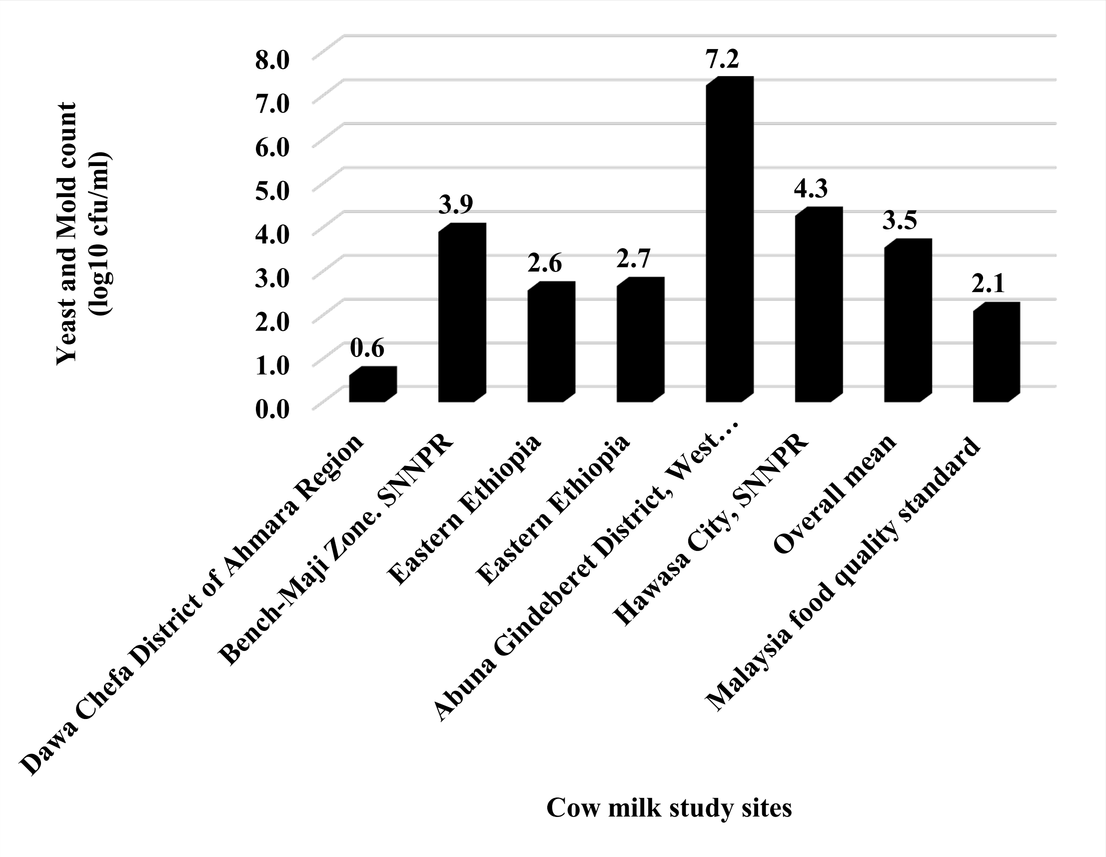


Figure 3: Comparison of Yeast and Mold count in cow milk samples in Ethiopia against Malaysia food quality standards

Table 2: Physicochemical contents (mean±SE) in cow milk samples in Ethiopia

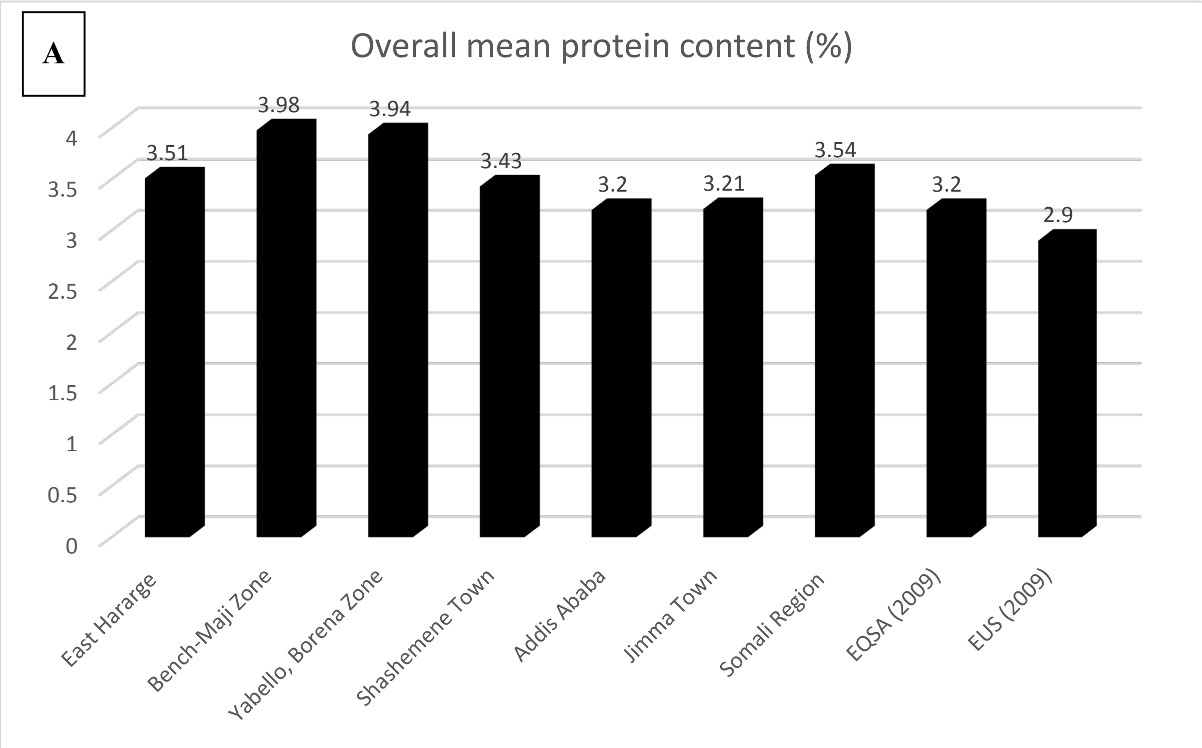
Fat (%)			**Protein (%)**			**Lactose (%)**			**SNF (%)**		
Overall mean	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***
4.19 ± 0.70	West Showa	Tadesse, 2020	3.51±0.63	East Hararge	Hawaz *et al*., 2015	3.79±0.69	East Hararge	Hawaz *et al*., 2015	7.6 ± 0.9	Addis Ababa	Biruktawit, 2016
4.38±0.06	Jimma Town	Belay and Janssens, 2014	3.980±0.41	Bench-Maji Zone	Teshome and Tesfaye, 2016	4.72+ 0.17	Gurmessa *et al*., 2015	3.54 ± 0.12	7.98±0.98	East Hararge	Hawaz *et al*., 2015
4.28±0.05	Shashemene Town	Teshome, *et al*., 2015	3.94+0.07	Yabello, Borena Zone	Gurmessa *et al*., 2015	4.34±0.13	Jimma Town	Belay and Janssens, 2014	8.59±0.07	Shasheme ne Town	Teshome, *et al*., 2015
5.54 ± 0.65	Somali Region	Legesse *et al*., 2017	3.43±0.00	Shashemene Town	Teshome, *et al*., 2015	5.39 ± 0.31	West Showa	Tadesse, 2020	9.46+ 0.17	Yabello, Borena Zone	Gurmessa *et al*., 2015
6.024±0.76	Bench-Maji Zone	Teshome and Tesfaye, 2016	3.2±0.33	Addis Ababa	Biruktawit, 2016				9.77 ± 0.58	West Showa	Tadesse, 2020
4.42 ± 1.16	Addis Ababa	Biruktawit, 2016	3.21±0.06	Jimma Town	Belay and Janssens, 2014						
6.01+ 0.09	Yabello, Borena Zone	Gurmessa *et al*., 2015	3.54 ± 0.12	Somali Region	Legesse *et al*., 2017						
5.12±0.84	East Hararge	Hawaz *et al*., 2015									

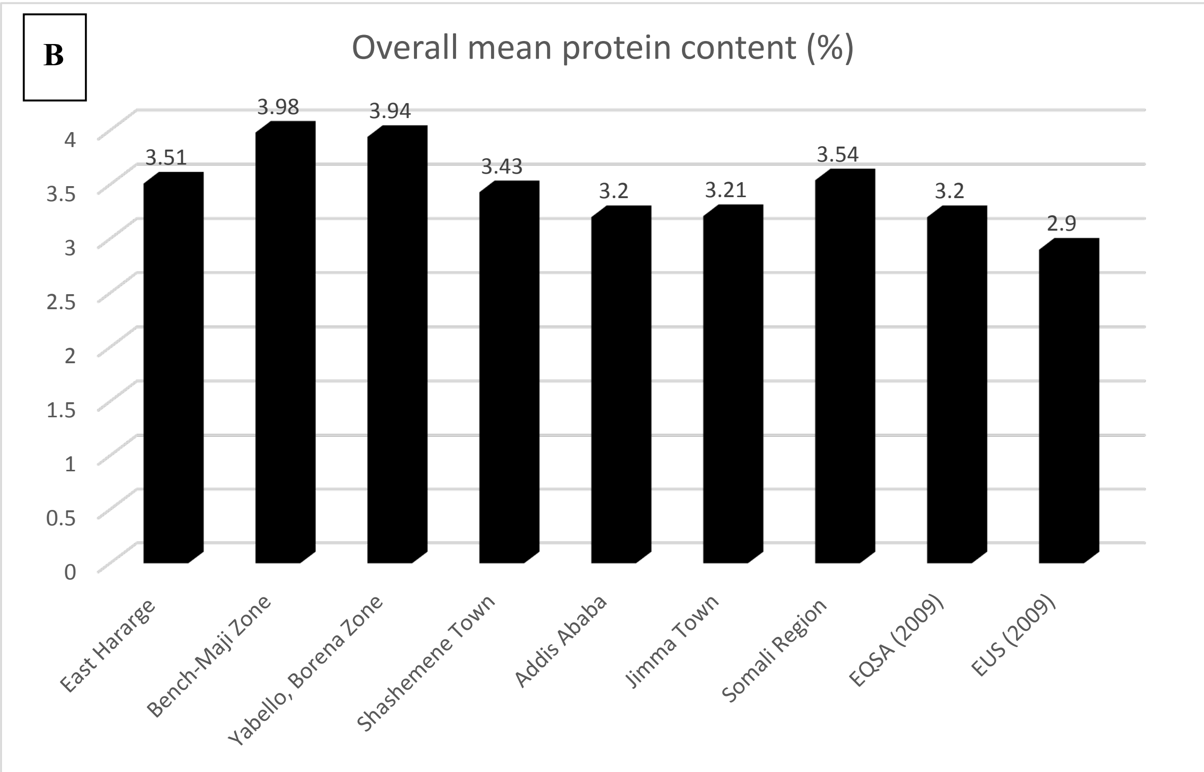
Ash content (%)												
Overall mean	***Study area***	***Reference***										
0.80± 0.015	Yabello, Borena Zone	Gurmessa *et al.*, 2015										
0.795± 0.056	Bench-Maji Zone	Teshome and Tesfaye, 2016										
0.75 ± 0.07	Somali Region	Legesse *et al.*, 2017										
0.74± 0.00	Shashemene Town	Teshome, *et al.*, 2015										
0.68± 0.16	East Hararge	Hawaz *et al.*, 2015										
0.78 ± 0.09	West Showa Zone	Tadesse, *et al.*, 2020										

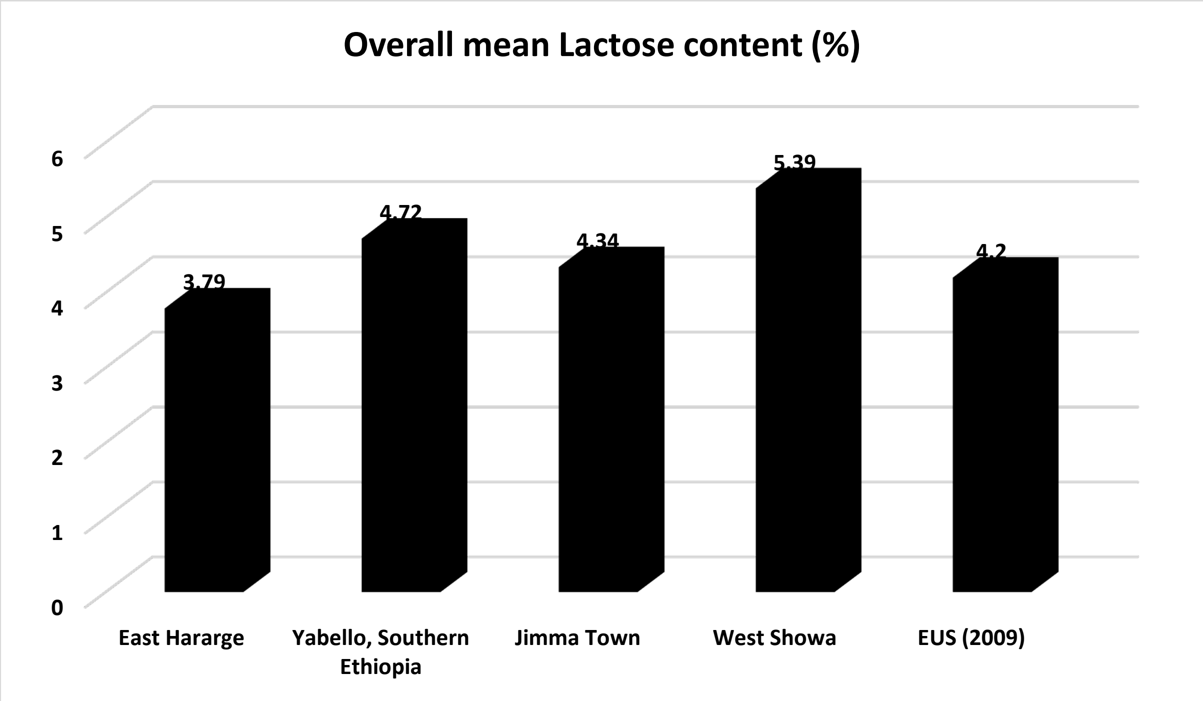
Physicochemical contents (Cont'd)

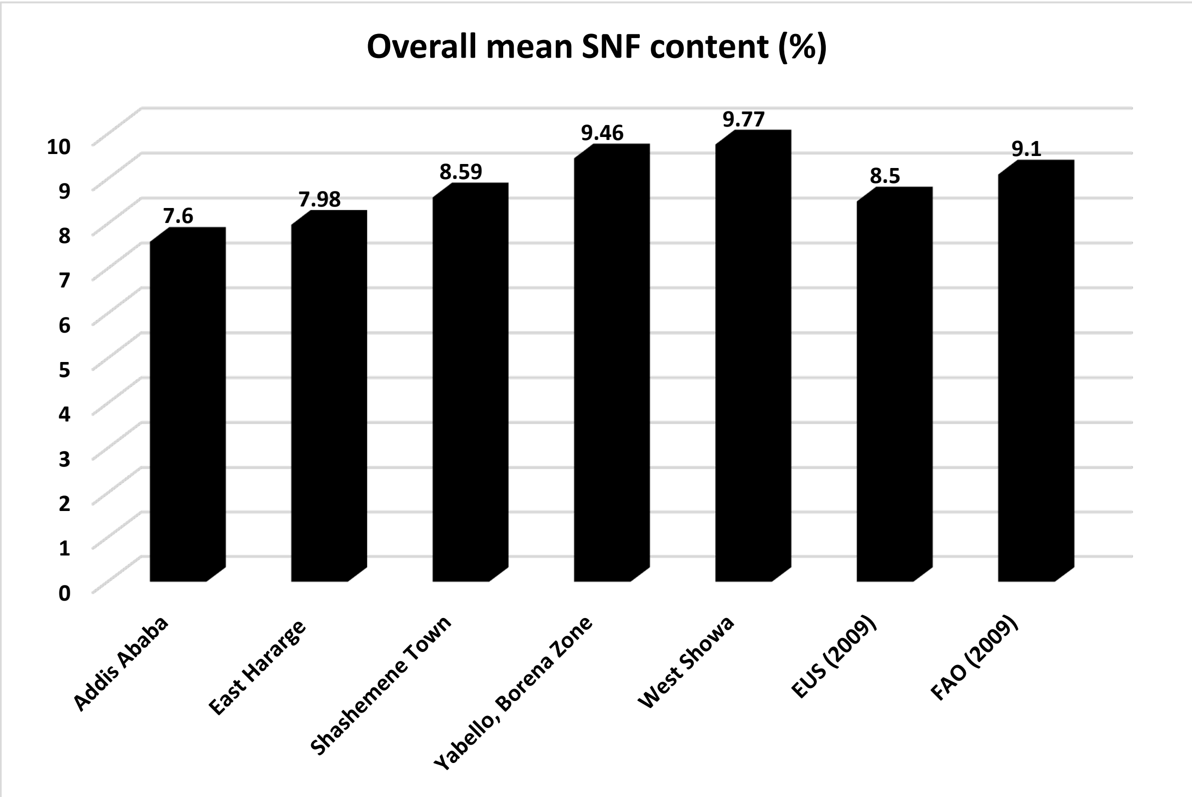
Total solids (%)			**Titratable acidity (%)**			**pH value**			**Specific gravity (gm/cm^3)**		
Overall mean	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***	***Overall mean***	***Study area***	***Reference***
14.60 ± 0.60	Somali Region	Legesse *et al.*, 2017	0.197+ 0.004	Yabello, Borena Zone	Gurmessa *et al.*, 2015	6.30 ± 0.15	Somali Region	Legesse *et al.*, 2017	1.06 ±0.03	Somali Region	Legesse *et al.*, 2017
15.47+0.15	Yabello, Borena Zone	Gurmessa *et al.*, 2015	0.25±0.05	East Hararge	Hawaz *et al.*, 2015	6.32±0.07	Shashemene Town	Teshome, *et al.*, 2015	1.022+0.001	Yabello, Borena Zone	Gurmessa *et al.*, 2015
13.10±1.28	East Hararge	Hawaz *et al.*, 2015	0.190±0.023	Bench-Maji Zone	Teshome and Tesfaye, 2016	6.39± 0.035	Yabello, Borena Zone	Gurmessa *et al.*, 2015	1.0325±0.0017	West Showa Zone	Tadesse, *et al.*, 2020
12.02 ± 1.79	Addis Ababa	Biruktawit, 2016	0.23± 0.01	Bahir Dar Zuria and Mecha District, Amhara Region	Asaminew and Eyasu, 2011	6.48±0.273	Bench-Maji Zone	Teshome and Tesfaye, 2016	1.030±0.00	Shasheme ne Town	Teshome, *et al.*, 2015
12.87±0.11	Shashemene Town	Teshome, *et al.*, 2015	0.38±0.18	West Showa Zone	Tadesse, *et al.*, 2020	6.47±0.42	West Showa Zone	Tadesse, *et al.*, 2020	1.028±0.010	Bench-Maji Zone	Teshome and Tesfaye, 2016
13.96 ± 1.10	West Showa	Tadesse, 2020	0.16 ± 0.04	Somali Region	Legesse *et al.*, 2017						

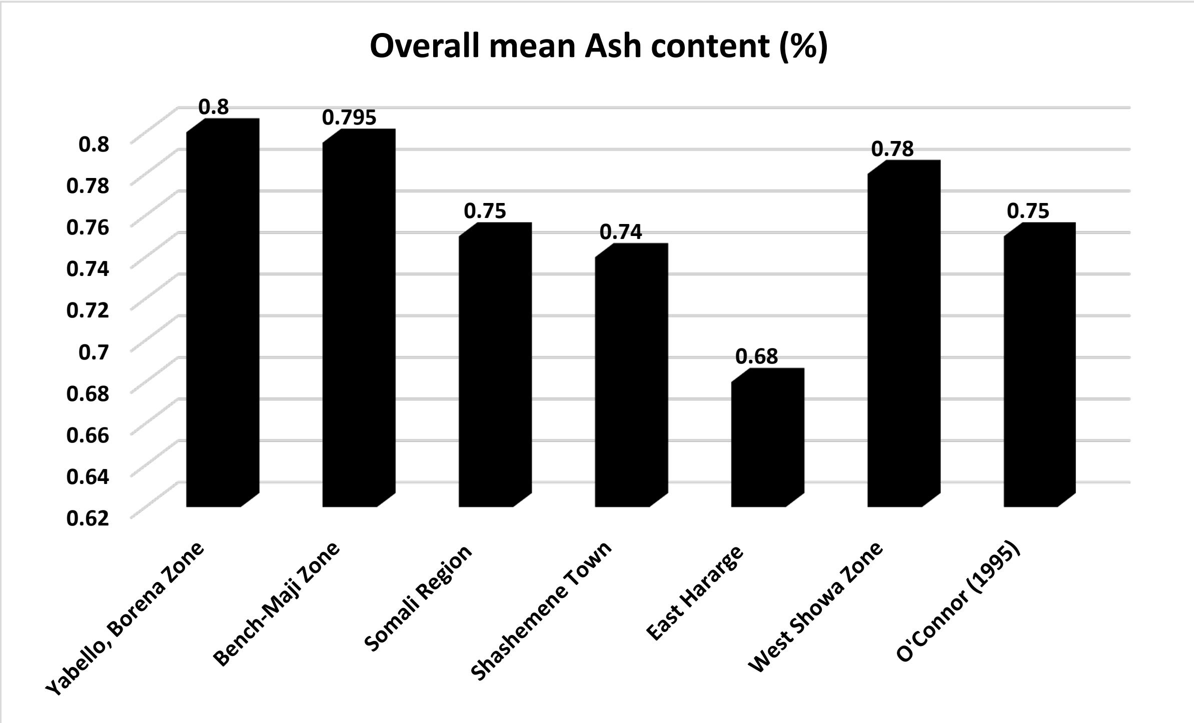
Note: SE=standard error; SNF=solid-not-fat

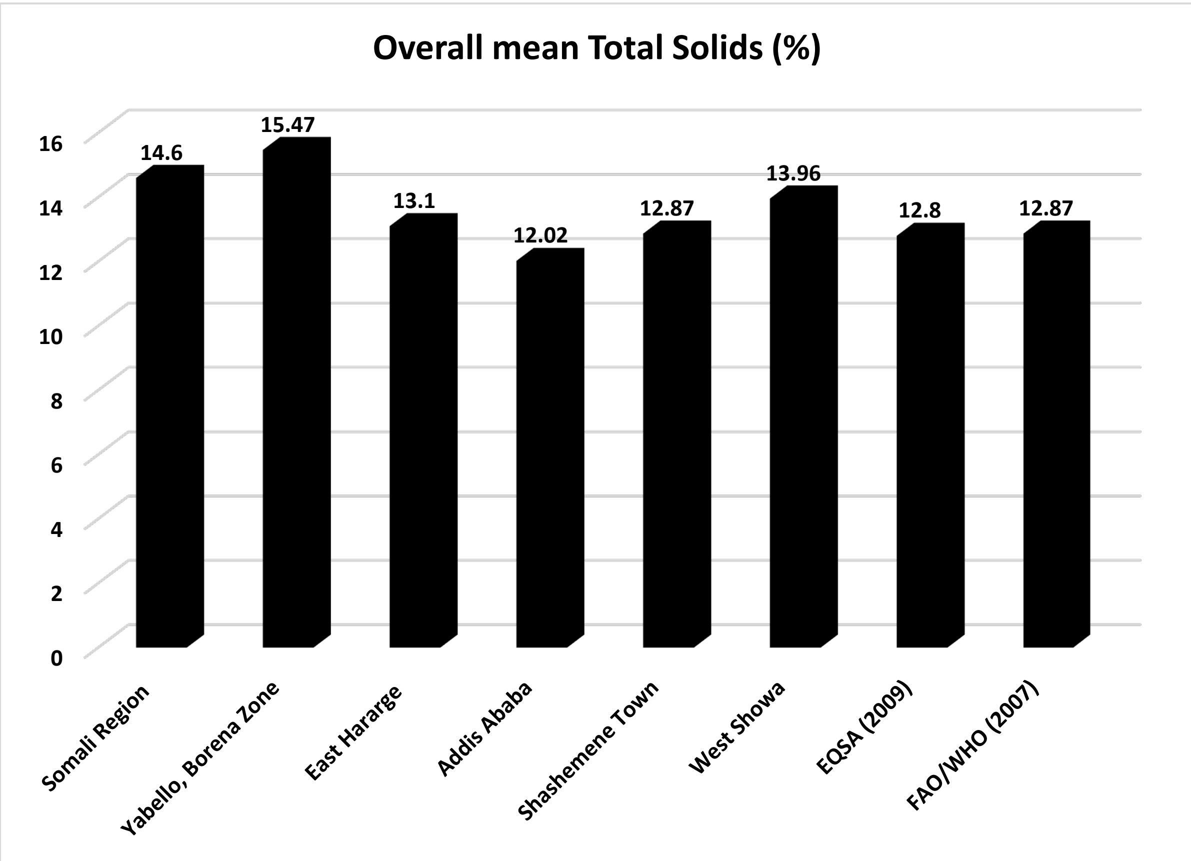

A
Overall mean protein content (%)
4
3.5
3
2.5
2
1.5
1
0.5
0
3.51
3.98
3.94
3.43
3.2
3.21
3.54
3.2
2.9
East Hararge
Bench-Maji Zone
Yabello, Borena Zone
Shashemene Town
Addis Ababa
Jimma Town
Somali Region
EQSA (2009)
EUS (2009)

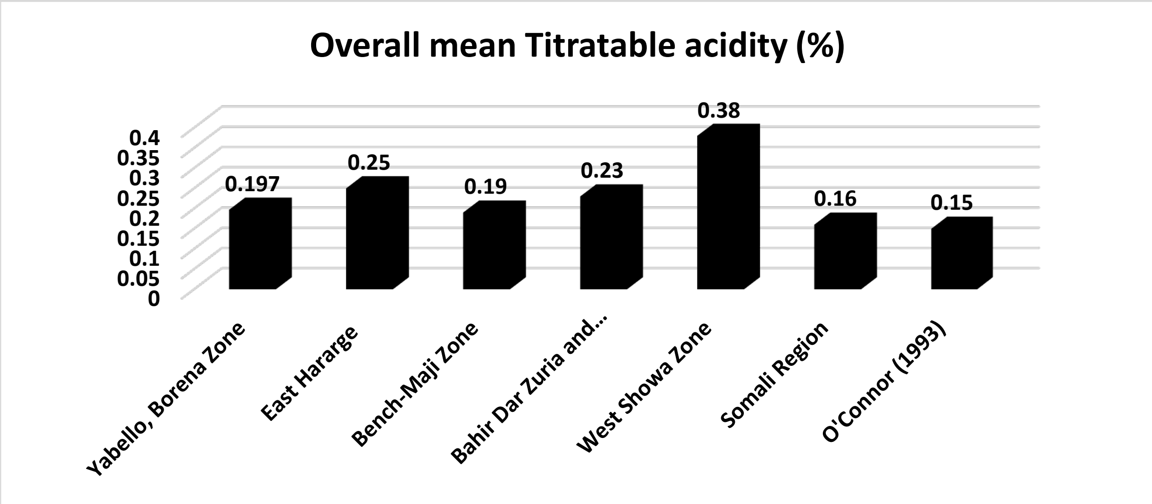

B
Overall mean protein content (%)
4
3.5
3
2.5
2
1.5
1
0.5
0
3.51
3.98
3.94
3.43
3.2
3.21
3.54
3.2
2.9
East Hararge
Bench-Maji Zone
Yabello, Borena Zone
Shashemene Town
Addis Ababa
Jimma Town
Somali Region
EQSA (2009)
EUS (2009)

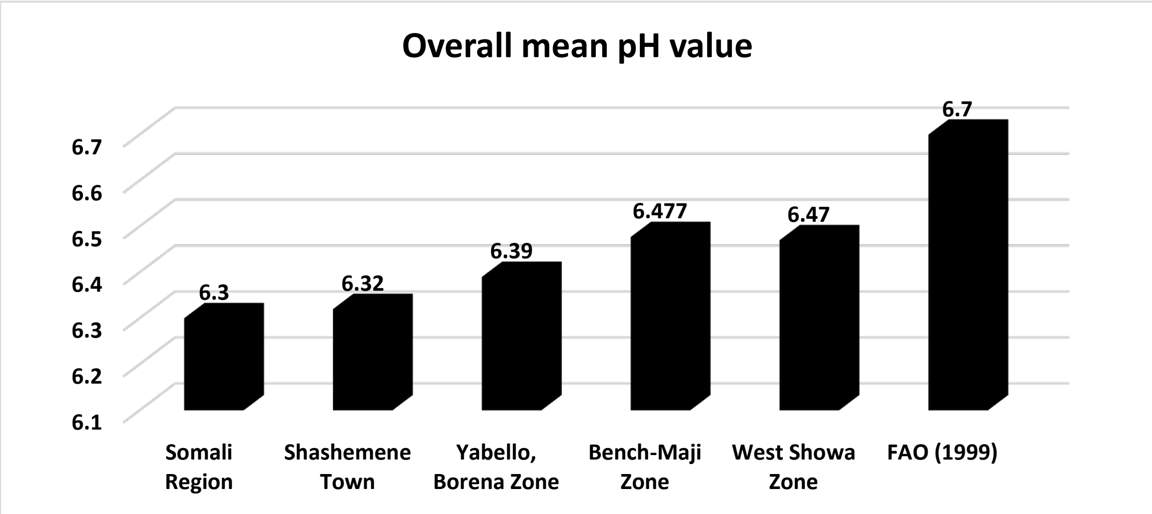

Overall mean Lactose content (%)
6
5
4
3
2
1
0
3.79
4.72
4.34
5.39
4.2
East Hararge
Yabello, Southern Ethiopia
Jimma Town
West Showa
EUS (2009)


Overall mean SNF content (%)
10
9
8
7
6
5
4
3
2
1
0
7.6
7.98
8.59
9.46
9.77
8.5
9.1
Addis Ababa
East Hararge
Shashemene Town
Yabello, Borena Zone
West Showa
EUS (2009)
FAO (2009)


Overall mean Ash content (%)
0.8
0.78
0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.8
0.795
0.75
0.74
0.68
0.78
0.75
Yabello, Borena Zone
Bench-Maji Zone
Somali Region
Shashemene Town
East Hararge
West Showa Zone
O'Connor (1995)


Overall mean Total Solids (%)
16
14
12
10
8
6
4
2
0
14.6
15.47
13.1
12.02
12.87
13.96
12.8
12.87
Somali Region
Yabello, Borena Zone
East Hararge
Addis Ababa
Shashemene Town
West Showa
EQSA (2009)
FAO/WHO (2007)





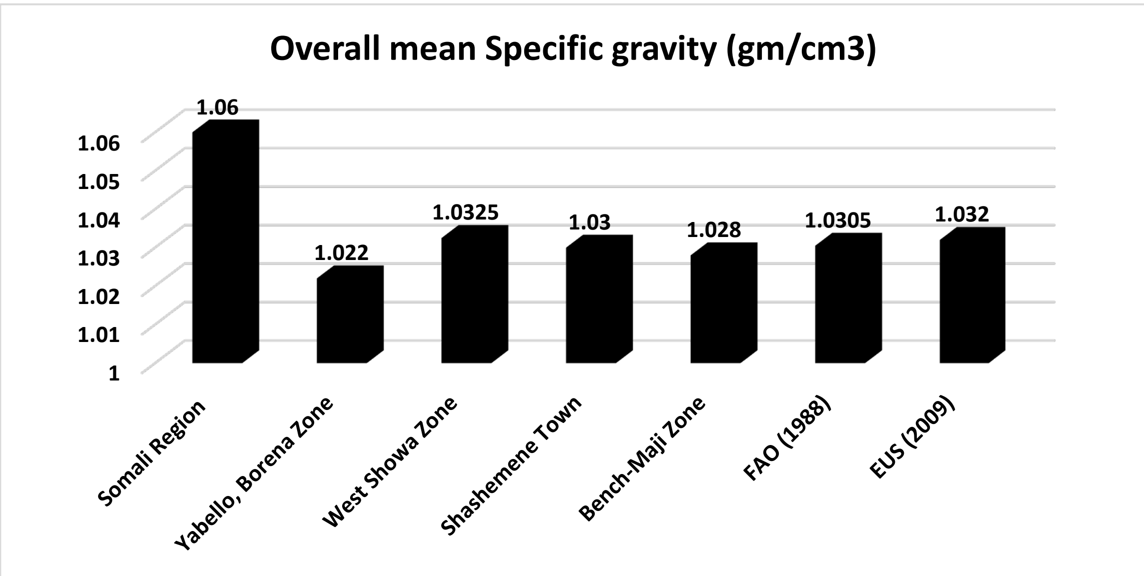


Figure 4: A) Fat, B) Protein, C) Lactose, D) SNF, E) Ash, F) Total solids G) Titratable acidity, H) pH value and I) content, Specific gravity in milk samples across Different parts of Ethiopia

Conclusion and Recommendation

Ethiopia is reported to have the highest population of the cattle herd in Africa and takes the third rank globally. However, due to the poor genetic makeup of the domestic breeds, inadequate and poor quality feed, a variety of diseases and parasites, the amount of milk produced is minimal. Moreover, the milk produced in most of the country is of poor quality.

Reports from cow milk microbial quality studies in different parts of the country so far indicated that the majority of the samples have failed to fulfill the quality standards set by East African Standard and European Community in terms of total bacterial and coliform counts. The overall mean of both the microbial categories across the reports reviewed considerably exceeded the threshold level set. Especially coliform counts in almost all of the samples studied were far beyond the maximum tolerable level. This is a good indication that there is a high probability that pathogenic species exist, grow and multiply in the milk being produced making it unsafe for raw consumption without appropriate treatment such as boiling or pasteurization. Moreover, studies from different parts of the country revealed that yeast and mold count in milk samples investigated was far above the standard set by Malaysian Food Quality Standards showing that the milk produced in most of the sampling Districts is subject to spoilage hence reduced shelf life. Moreover, the presence of fungal microflora is associated with the production of hazardous mycotoxins which are even resistant to thermal destruction aggravating the hazard associated. Comparison of the fat content against the standards set by the Ethiopian Quality Standards Authority (EQSA), East African Standards, and European Union Standards showed that the majority of the milk samples were in the acceptable range. Studies have revealed that fat content is considerably influenced by agroecology and breed type. Similarly, protein content of most of the milk samples except those collected from Addis Ababa City and Jimma Town was above or equivalent to the values set by EQSA and EUS. The highest fat and protein content was recorded in Bench Maji and Borena Zones alike. All the lactose values reported were beyond the values set by EUS. Studies in East Hararghe and West Showa Zones presented a leading lactose content. Samples collected from Addis Ababa and East Hararghe Zones didn't qualify in terms of SNF content as compared to EUS AND FAO (2009) standards with West Showa Zone taking first place in this parameter. Ash and total solid content analysis showed that a higher proportion of the samples studied across the country were in an acceptable range according to O'Connor (1995), EQSA (2009), and FAO/WHO (2007) with samples from Yabello, Borena Zone taking the lead. Based on the standards mentioned by O'Connor (1993), almost all of the samples investigated in the country failed to fulfill the quality standards in terms of titratable acidity. This shows a higher lactic acid content hence significant mishandling practices prevailing in most parts of the country. This corresponds to the lower pH values recorded in almost all of the reports so far. Most of the milk studies reported that the majority of the sample has fallen in the acceptable range for normal cow milk about specific gravity. In general, cow milk resources being produced in Ethiopia are of acceptable quality from physical properties and chemical constituents point of view. Microbial quality of cow milk being produced needs to be improved through training of the household, smallholder, and cooperative dairy producers about hygienic practices in pre, during and post-production and subsequent handling of cow milk for enhanced safety for local consumption and acceptability for industrial processing. Apart from microbial load and physicochemical quality studies, the status of milk safety in terms of contamination with mycotoxins, residues from agricultural chemicals, and other impurities posing serious human health concerns should be widely studied.

Conflict of Interest

Microbial quality is an important parameter to judge the standard of cow milk and its acceptability for consumption and further industrial and smallholder processing. Moreover, physical properties and chemical constituents are considerably varying based on breed, feed type and quality, and agroecology in which milk is produced. This review in general had shown a clear picture of the standards of cow milk production in Ethiopia about microbial and physicochemical qualities so that those responsible in this sector will be well aware of the importance of training of the producers and major actors across the dairy value chain in the country.

REFERENCES

Abebe, B., Zelalem, Y. and Ajebu, N., 2012. Hygienic and microbial quality of raw whole cow's milk produced in *Ezha* district of the Gurage zone, Southern Ethiopia. *Wudpecker J. Agri. Res.* 1(11): 459 – 465

American Public Health Association, 1992. APHA method 9221: Standard Method For the Examination of Water and Waste Water, 18th ed. Washington DC.

Asaminew, T. and Eyassu, S., 2011. Microbial quality of raw cow's milk collected from farmers and dairy cooperatives in Bahir Dar Zuria and Mecha district, Ethiopia. *Agric. Biol. J. of N. Am.* 2(1): 29-33.

Biruktawit, SH., 2016. Physicochemical Properties And Microbial Quality Of Cow Milk Collected From Selected Sub-city Of Addis Ababa, Ethiopia. M.Sc Thesis, *Addis Ababa University, College of veterinary Medicine and Agriculture, Department of Animal Production Studies.*

Bodman GR and Rice DN (1996) Bacteria in Milk in Source and Control. University of Nebraska and United State Department of Agriculture, USA.

Chambers JV., 2002. The microbiology of raw milk in Dairy Microbiology Handbook. 3rded. R. K. Robinson, ed. John Wiley & Sons Inc., New York.

CSA, 2011. Agricultural Sample Survey. Central Statistical Authority. Survey Report on Livestock and Livestock Characteristics (Private Peasant Holding. Volume II. Addis Ababa, Ethiopia, pp: 9-26

Derese, T. 2008. Present situation of urban and periurban milk production and quality of raw milk produced in west Shewa Zone, Oromia Region. MS.c. Thesis, Haramaya University, Haramaya, Ethiopia.

EAS, 2007. *Raw Cow Milk – Specification.* East African Community (EAC 67:2007) standard. pp 1 - 19.

FAO/WHO, 2006. Benefit and Potential Risk of the Lactoperioxidase system of Raw milk preservation. Report of an FAO/WHO Technical Meeting FAO Head Quarters, 28th, Nov 2nd Dec, 2005, Rome, Italy.

Fekadu, B., 1994. Present situation and future aspects of milk production, milk handling and processing of dairy products in Southern Ethiopia. PhD Dissertation presented to Agricultural University of Norway

Food and Agriculture Organization (FAO), 1988. The Technology of Traditional Milk Products in Developing Countries. *Animal production and Health Paper. No. 85*. Food and Agriculture Organization of the United Nations. Rome, Italy.

Fufa, A., Nigus, T., Fikru, R., Dinka, A. and Kebede, A.**,** 2019**.** Handling Practices, Quality and Safety of Milk along the Dairy Value Chains in Selected Sub Cites of Addis Ababa, Ethiopia. *Biomed J. Sci. & Tech. Res.* Vol. 13(1): 9652-9665

Gamal, M. H., Arafa, M. S. M. and Soad, M. G., 2015. Microbiological quality and safety of fluid milk marketed in Cairo and Giza Governorates. *Current Research in Dairy Science*, 7 (1): 18-25.

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.

Hawaz, E., Tarekegn, G., Yonas, H., Eyassu, S., Mengistu, K. and Mohammed, A., 2015. Physicochemical Properties and Microbial Quality of Raw Cow Milk Collected from Harar Milkshed, Eastern Ethiopia. *J. Biol. Chem. Research*. Vol. 32, No. 2: 606-616.

Heeschen W.H. (1997). The Significance of Pathogenic Micro-Organisms in Raw Milk. International Dairy Federation.

Legesse, A., Adamu, F., Alamirew, K., Feyera, T., 2017. A Comparative Study on the Physicochemical Parameters of Milk of Camel, Cow and Goat in Somali Regional State, Ethiopia. Chem Sci J 8: 171. doi:10.4172/2150-3494.1000171

Melese, A. and Tesfaye, W. 2015. Bacteriological quality and safety of raw cow's milk in and around Jigjiga City of Somali Region, Eastern Ethiopia. *International Journal of Research Studies in Biosciences (IJRSB),* 3 (5): 48-55.

Nalwaya, S.B., Prajapati, B.I., Bariya, A.R., Goswami, M.M. and Roy, S.K., 2018. Evaluation of Physico-Chemical and Microbiological Quality of Milk of Banaskantha District, India. *Int. J. Curr. Microbiol. App. Sci. 7*(12): 1635-1641

Nanu, E., Latha, C., Sunil, B. and Thomas, M., 2007. Quality assurance and public health safety of milk at the production point. *American Journal of Food Technology* 2: 145-152.

O'Connor, C.B., 1993. *Traditional Cheese Making Manual*. ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia. 43 pp.

O'Connor, C.B., 1995. Rural Dairy Technology ILRI Training Manual I, International Livestock Research Institute, Addis Ababa, Ethiopia.

Rahel. N., 2008. Traditional and Improved Milk and Milk Products Handling Practices and Compositional and Microbial Quality of Milk and Buttermilk in Delbo Watershed of Wolayta Zone, M.Sc.Thesis. Department of Animal and Range Sciences, Hawassa College of Agriculture, School of Graduate Studies, Hawassa University, Ethiopia.

Solomon, A., Mitku, E., Getachew, A. and Kefyalew, G., 2015. Microbial Quality of Cow Milk in Dawa Chefa District, Amhara Region, Ethiopia. *J. Adv. Dairy Res.* 3:2. DOI: 10.4172/2329-888X.1000135.

Spreer, E., 1998. Milk and Dairy Product Technology. Marcel Dekker Inc, New York, USA.

Tadele, A., Ameha, K., Yoseph, M. and Mitiku, E., 2016. Microbiological Quality of Raw Cow Milk across the Milk Supply Chain in Eastern Ethiopia. *East African J. of Sci.* 10(2): 119-132.

Tadesse, A., Galmessa, U., & Bekuma, A., 2020. Milk Handling, Processing Practices and Quality Evaluation. *Global Journal of Animal Scientific Research,* 8(1), 56-74.

Teshome, G. and Tesfaye, A., 2016. Physicochemical Properties and Microbial Quality of Raw Cow Milk Produced by Smallholders in Bench Maji-Zone, Southwestern Ethiopia. *J. Food Sci. and Qual. Manag.* Vol. 55: 55-62.

Torkar KG, vengust A (2008) The presence of yeasts, moulds and aflatoxin M1 in raw milk and cheese in Slovenia. Food control 19: 570-577.

Walstra P, Geurts TJ, Noomen A, Jellema A and Van Boekel MAJS (1999). Dairy Techniology: Principles of Milk Properties and Processes. 1st.ed. Newyork: Marcel Dekker. PP 149-170.

Wanjala, G.W., Mathooko, F.M., Kutima, P.M. and Mathara, J.M., 2017. Microbiological Quality And Safety Of Raw And Pasteurized Milk Marketed In And Around Nairobi Region. *African J. F. Agri. Nutri.* and *Develop.* 17(1): 11518-11532.