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Physicochemical analysis and microbial quality of raw cow's milk along with production system in Angolelanatera district, Amhara region, Ethiopia

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ABSTRACT

This study was conducted to determine physicochemical analysis and microbial quality of raw cow's milk along with the production system in the study area. Data was collected by conducting experimental activities and survey. Statistical package for social science (SPSS) were used to analyze data. The main income sources of the respondents were mixed agriculture (92.5%) and 44.5% respondents had basic education. 78.3% respondents believed the milk quality of local cows were better than cross cows. Natural grazing, crop residues and conserved hay (54.6, 41.8 and 3.6) % were the main feed resources in the study area respectively. The only improved forage species were oat and vetch but most respondents feed these forage species after the seed was collected. The maximum mean of fat and protein content of cow's raw milk in the study areas were 5.30±0.28 and 3.29±0.05 in Chekiy local cows and Chefanen cross cows respectively. The highest total bacterial and coli form count was recorded in Tsigereeda and Chacha kebeles ($3.75x10^8$ and $2.16x10^5$) respectively. The average number of yeast and mold was $1.56x10^5$, $1.97x10^5$, $2.14x10^5$ and $1.73x10^5$ in Tsigereda, Chekiey, Chefanen and Chacha respectively. The highest bacterial and coli form count was recorded due to poor hygienic practice.

Interventions about hygienic practice will solve the listed problems.

1. Introduction

Milk and milk products play an important role in human nutrition throughout the world. It provides a near perfect diet for most young animals and it is one of the most common food sources in the human diet and is also a product that is directly available for consumption (Grimaud, 2009). The quality of milk as well as its safety in the consumption depends on its chemical composition, microbiological, physical and organoleptic properties. The composition of milk varies with season, stage of lactation, feeding, health status of the cow, milking interval, genetic factors and other day to day variation (Heck et al., 2009). Due to its complex biochemical composition and high water activity, milk and milk products serve as an excellent medium for the growth and proliferation of many kinds of microorganisms (Rahman et al., 2008; Murinda et al., 2004; Oliver et al., 2005).

The safety of raw cow milk is influenced by a combination of management and control measures along the entire dairy supply chain. The rate of microbial contamination of cow's raw milk is influenced by the health status and hygiene cow, hygiene of housing and milking area, methods of udder preparation and milking techniques, methods of cleaning and disinfection of milking machines and milk tanks, hygiene of the attendant staff (Cempirkova, 2007). The presence and the multiplication of microorganisms cause changes in the quality of the milk, thereby limiting its durability and bringing harm to the economy and public health (Lilian et al., 2012).

Angolelanatera district is one of the most milk shed area in North Shoa Zone, which supply raw milk for Addis Ababa market, but there is limited or no work undertaken to understand the hygienic practices, physicochemical properties and Microbial quality of milk. In this background, the present study is intended to describe the physicochemical composition and microbiological quality of cow`s milk along with production system and it helps to improve and intervene.

2. Materials and methods

The study was conducted in Angolelanatara district, North Shoa Zone of Amhara Regional State, Ethiopia. 180 respondents were randomly selected from 6 kebeles for surveying and 120 and 40 milk samples were taken from 4 kebeles for physicochemical analysis and microbial quality test respectively and left in the laboratory without any coagulation for further evaluation. The samples were aseptically collected using sterile universal bottle. The samples were transported in ice-packed flask to the laboratory. Physicochemical properties of the milk samples were analyzed according to Richardson (1985) and specific gravity of the milk samples were determined by a Lactometer. The microbiological counts of milk samples considered were total bacterial count, Coliform count (CC) and yeast and mould count (YMC). For determination of these counts Richardson (1985) methodology were used. The media used for these purpose were prepared according to the guidelines given by the manufacturers. Each count was done in duplicate. To count coliform and yeast and mold count 1 ml of milk sample was added into sterile test tube having 9 ml of peptone water. After mixing, the sample were serially diluted up to 1: 10^{-3} dilution level and duplicate samples (1ml) were pour plated using 15 - 20ml of molten Violet Red Bile agar (coliform) and molten potato dextrose agar (yeast and mold). After thorough mixing, the plated sample were allowed to solidify and incubated at 30^0C for 24 hours (coliform) and at 25^0C for 5 days (yeast and mold). Finally, colony counts were made using colony counter Abdel-Rahman et al. (2009) and Marth (1978). The estimated number of colonies per ml of sample was calculated using the following formula (IDF, 1991).

$$\text{Count} = Sk / (n_1 + 0.1n_2) \times d$$

Where,

SK= sum of all colonies counted (between 10 and 300) for total bacteria count

n_1 = number of plates from the lowest dilution used for computing the count

n_2 = number of plates in the next dilution level used for computing the count

d = reciprocal of the dilution factor of the lowest dilution used for computing the corresponding to n_1

3. Results

3.1. General household characteristics of the study area

In the study area 87.7% and 12.3% respondents were male and female respectively. The average family size of the respondents was about 5.5 and the main income sources were mixed agriculture and non-farm and livestock production (92.5 and 7.5) % respectively. With regard to educational background majority of the respondents (44.5%) had basic education and the rest (25.5, 25.5 and 4.5) % was primary school, secondary school and illiterate respectively (Table 1).

Table 1
Characteristics of household.

	Kebeles (n=180)						
Activities	**Serity**	**Tsigereda**	**Chekiy**	**Buran**	**Chefanen**	**Chacha**	**Total**
Sex of respondent							
Male	70	90	100	90	80	75	87.3
Female	30	10	0	10	20	25	12.7
Family size (mean)	5.5±0.5	5.5±0.5	6.3±0.5	5.8±0.5	5.0±0.5	4.5±0.7	5.5±0.2
Level of education							
Illiterate	5	5	0	5	10	0	4.5
Basic education*	55	55	35	20	65	30	44.5
1-8th grade	30	30	45	30	2	20	25.5
9-12th grade	10	10	20	45	5	50	25.5
Income source							
Crop and livestock	100	100	75	100	100	80	92.5
Nonfarm & livestock	0	0	25	0	0	20	7.5

N= Number of respondents and * includes religious education.

3.2. Farmer's criteria to identify the quality of cow raw milk

Most respondents (71%) reported that the quality of milk was different in different breeds and 78.3% respondents said local cows has high quality milk yield as compared to cross cows (Table 2). The criteria's that the respondent used to know the quality of cow's milk were fat content of milk, taste and odor, colour and colour, taste and odor (21.7, 70.8, 2.5 and 5)% respectively.

Table 2
Criteria to identify the quality of milk in different breed.

	Kebeles (n= 180)						
Criteria	**Serity**	**Tsigereda**	**Chekiy**	**Buran**	**Chefanen**	**Chacha**	**Total**
Is quality differ in breeds							
Yes	85	75	65	60	78	63	71
No	15	25	35	40	22	37	29
Have high milk quality							
local	75	80	85	70	70	90	78.3
cross	25	20	15	30	30	10	21.7
Quality of milk in							
Fat content	15	0	35	10	40	30	21.7
Taste and odor	45	95	65	90	60	70	70.8
Colour	10	5	0	0	0	0	2.5
Combination*	30	0	0	0	0	0	5

n= number of respondents and combination*= combination of fat content, taste, odor and color.

3.3. Main sources of animal feed

Respondents reported that natural grazing, crop residues and conserved hay (54.6, 41.8 and 3.6) % were the main feed resources in the study area respectively. According to focus group discussion, most respondents (85%)

used agro-industrial by products as a supplementary feed and 47.7% of respondents grow improved forage species but the feeding and cultivation of improved forage species in the study area was not satisfied. The only improved forage species which was common in the study area were oat and vetch and most respondents feed these forage species after the seed was collected (Table 3).

Table 3
Feed resource and supplementary feed.

	Kebeles (n=180)						
Variables	**Serity**	**Tsigereda**	**Chekiy**	**Buran**	**Chefanen**	**Chacha**	**Total**
Major feed resources							
Natural grazing	95	20	15	70	75	50	54.6
Crop residues	5	80	85	30	5	50	41.8
Conserved hay	0	0	0	0	20	0	3.6
Cultivation of improved forages							
Yes	73.7	50	0	65	60	30	47.7
No	26.3	50	100	35	40	70	52.3
Offering supplementary feed							
Yes	100	100	100	100	90	100	98.2
No	0	0	0	0	10	0	1.8

Atella* = Locally fermented alcohol by product ("Arekey" and "Tella").

3.4. Milk handling practice

Most (63.1%) respondents wash their hands before milking, but 82.9% of respondents did not wash their dairy cow's udder before milking. 91.8 and 89.4 of dairy owner clean utensils and barn every milking time and once a day respectively. According to focus group discussion those dairy owners did not wash their hand with soap and they have not used towels for udder cleaning (Table 4).

Table 4
Milk handling practices.

		Kebeles (n=180)						
Milk hygiene activity (%)		**Serity**	**Tsigereda**	**Chekiy**	**Buran**	**Chefanen**	**Chacha**	**Total**
Hand wash	Yes	65.3	60.0	62.2	62.4	57	71.5	63.1
before milking	No	34.7	40.0	37.8	37.8	43	28.5	36.9
Udder wash	Yes	21.4	15.2	13	12.5	16.9	23.3	17.1
before milking	No	78.6	84.8	87	87.5	83.1	76.7	82.9
Utensil	Once a day	5.0	9.3	8.8	7.4	6.0	12.5	8.2
washing	Any milking time	95.0	90.7	91.2	92.6	94.0	87.5	91.8
	Once a day	92.5	91.1	88.2	92.3	91.4	81.3	89.4
Barn cleaning	Twice a day	7.5	9.9	11.8	7.7	8.6	16.7	10.3
	Three times a day	0	0	0	0	0	2.0	0.3

N=number of sampled respondents.

3.5. Physicochemical analysis of cow's milk

The fat contents of cow's milk were in the range of 3.89±0.29-5.30±0.28. The lowest and highest fat content was recorded in Tsigereda cross cows and Chekiy local cows respectively. The maximum and minimum protein content of cow's milk was 3.29±0.05 and 2.12±0.14 in Chefanen cross cows and Tsigereda local cows respectively. With regard to freezing point and density of sampled milk collected from Chefanen and Tsigereda local cows were highest (-0.55±0.01 and 2.00±0.98) respectively. The highest solid not fat content of milk was recorded samples collected from Chefanen (7.82±0.14). The highest and lowest added water in the study area was 37.50±4.96 and 2.59±0.93 Tsigereda local cows and Chefanen cross cows (Table 5).

Table 5
Physicochemical analysis of cow milk.

Kebeles	Fat%	Protein	SNF	Density	Add water	Freezing point
TRC	3.89±0.29	3.05±0.10	7.18±0.27	1.03±0.00	9.19±2.60	-0.51±0.02
CHL	4.64±0.34	3.22±0.09	7.62±0.23	1.03±0.00	5.58±1.90	-0.53±0.01
CFL	5.05±0.258	3.12±0.09	7.34±0.24	1.03±0.00	7.10±2.09	-0.52±0.01
CHC	4.50±0.62	3.05±0.16	7.15±0.44	1.84±0.67	10.68±4.96	-0.46±0.04
CFC	4.42±0.26	3.29±0.05	7.82±0.14	1.03±0.00	2.59±0.93	-0.55±0.01
CKC	5.01±0.28	3.27±0.10	7.75±0.28	1.05±0.02	3.97±2.49	-0.54±0.02
CKL	5.30±0.28	3.21±0.16	7.58±0.44	1.03±0.00	7.62±2.78	-0.53±0.02
TRL	3.92±0.23	2.12±0.14	4.59±0.40	2.00±0.98	37.50±4.96	-0.34±0.03

TRC (Tsigereda cross cows), CHL (Chacha local cows), CFL (Chefanen local cows), CHC (Chacha cross cows), CFC (Chefanen cross cows), CKC (Chekiy cross cows), CKL (Chekiy local cows and TRL (Tsigereda local cows).

3.6. Microbial quality analysis of raw cow's milk

The total bacterial count in Chacha, Chekiey, Chefanen and Tsigereda was $3.13x10^8$, $2.83x10^8$, $3.27x10^8$ and $3.75x10^8$ respectively and the total Coliform count was $2.16x10^5$, $2.13x10^5$, $1.96x10^5$ and $1.82x10^5$ in Chacha, Chekiey, Chefanen and Tsigereda respectively. The average number of yeast and mold was $1.56x10^5$, $1.97x10^5$, $2.14x10^5$ and $1.73x10^5$ in Tsigereda, Chekiey, Chefanen and Chacha respectively (Table 6).

Table 6
Microbial quality analysis of raw cow's milk.

	Parameter tested (S=40)		
Study Kebeles	TAMBC (CFU/ml)	T. Coli form (CFU/ml)	Yeast & molds (CFU/ml)
Chacha	3.13x108	2.16x105	1.73x105
Chekiey	2.83x108	2.13x105	1.97 x105
Chefanen	3.27 x108	1.96x105	2.14x105
Tsigereda	3.75x108	1.82x105	1.56x105

S= sample size.

4. Discussion

4.1. General household characteristics of the study area

Most (87.7%) respondents were male and the average family size was about 5.5 which were similar with Abdi (2013) who reported 5.42 but smaller than Asaminew and Eyasu (2009) and Belay et al. (2011) who reported average family size of 8.2, 7.2 and 6.0 in Bahir Dar zuria, Mecha woreda and Jimma town respectively. 54.6% of respondents used natural grazing which were lower than Seid and Berhan (2014) who reported 92.6% natural pasture as feed resource in highland and mid-altitude areas.

4.2. Physicochemical analysis of cow's milk

The fat contents of cow's milk were in the range of 3.89±0.29-5.30±0.28. The main difference is due to breed and feeding system. The fat content of present study was higher than the fat content reported by Leila et al. (2014) 3.39 and 3.41% in summer and winter season, Asif and Sumaira (2010) 3.44-4.96 but lower than Samia et al. (2009) 4.14%. Comparable result was reported by Marimuthu et al. (2013) 4.43 ± 0.50 and 4.05 ± 0.01%. The fat content of present study is within the recommended standard of milk fat (3.5%). The best protein content of raw cow's milk were recorded in Chefanen cross cows (3.29±0.05). The current study result was comparable with Gabriel et al. (2011) who reported 3.05 and 3.51, Leila et al. (2014) who reported 3.01% in winter season and Marimuthu *et* al. (2013) who reported 3.24 ± 0.01% in Puliyampatti village, but lower than the result reported by Leila et al. (2014) 3.71% in summer season, Asif and Sumaira (2010) 3.87% and Ibrahim et al. (2013) 3.93% and Samia et al. (2009) 3.48 %. According to European standard of milk protein content (2.9%) present study is within the recommended standard. According to the recommended standard of European Union the solid not fat content of

unprocessed milk should not less than 8.50% Tamime (2009). Therefore, the solid not fat content of present study result was bellowing the recommended standard.

4.3. Microbial quality analysis of raw cow's milk

The total bacterial count, total coli form count and total *E.coli* count of raw cow milk potentially reveals the general conditions of sanitation and temperature control under which raw milk were produced, handled and held. The total bacterial count in Chacha, Chekiey, Chefanen and Tsigereda was $3.13x10^8$, $2.83x10^8$, $3.27x10^8$ and $3.75x10^8$ respectively. The obtained resul was higher than Edward and Inya (2013) who reported the minimum and maximum total bacterial count of raw cow's milk ($9.88 x10^7$ to $1.26 X 10^8$cfu/ml), Aberra (2010) who reported the mean values of total bacterial counts $7.78 x 10^6$ cfu/ml from raw milk samples in and around Addis Ababa, Bekele and Bayileyegn (2000) who reported the mean values of total bacterial counts $1.1 x 10^5$ cfu/ml from the producer's bucket and $4 x 10^6$ cfu/ml from storage containers before cooling, Alganesh (2007) reported total bacterial count of $7.4 x 10^7$ and $2.0 x 10^7$ cfu/m of cows' milk produced in Bila Sayo and Guto Wayu districts, Abebe et al. (2012.) who reported 9.82 log cfu/mL from raw cow's milk of Ezha district, Asrat (2010) who reported 6.36 log/cfu/mL in *Wolayta* zone but lower than Rahman et al. (2008) who reported the highest bacterial count ($4385.66×10^7$ cfu/g) and the lowest ($37.0×10^7$ cfu/g). Generally, the total bacterial count of present study 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) and John (1995) in USA. This high level of contamination of milk might be due to initial contamination originating from the udder surface, quality of cleaning water, milking utensils and materials used for filtering the milk. Total Coli form (CFU/ml) was $2.16x10^5$, $2.13x10^5$, $1.96x10^5$ and $1.82x10^5$ in Chacha, Chekiey, Chefanen and Tsigereda respectively. This result was in agreement with Abebe et al. (2012) reported 4.03 log cfu/mL, Rahel (2008) 4.03 log cfu/mL reported for milk samples collected from cows kept under traditional condition in the *Wolayta* zone, Rahman et al. (2008) who reported the highest coliform count at Varamara (9.86MPN/g) and the lowest at Rajshahi town (0.78MPN/g) and Asaminew (2007) who reported 4.84 logcfu/mL in milk samples collected in the *Bahir Dar* milkshed areas. The average number of yeast and mold was $1.56x10^5$, $1.97 x10^5$, $2.14x10^5$ and $1.73x10^5$ in Tsigereda, Chekiey, Chefanen and Chacha respectively. Karmen and Slavica (2008) reported the average number of yeasts and moulds in raw milk samples in summer (2.49 log10 cfu/ml) than in winter (2.23 log10 cfu/ml).

5. Conclusion

The main income sources of the respondents were mixed agriculture and the cultivation of improved forage species in the study area was very poor. The physicochemical quality of raw milk in the study area was very impressive and it was within the recommended standards of raw cow's milk of Ethiopia and Europe, but the microbial quality of the milk was below the standard level. The main cause of high microbial load in raw cow's milk in the study area was poor sanitation/hygiene. Producers should be washed their hands and udder of cow before milking, the milking utinsels should be cleaned, and unhealthy cows should be treated.

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