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Physicochemical Properties of Raw Milk Collected from Different Value Chain Points in Central Ethiopia

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Abstract: Milk is a translucent white liquid, produced by the mammary glands of mammals with high nutritional value, providing the primary source of nutrition for young mammals before they are able to digest other types of food. This study was conducted to evaluate physical and chemical quality of cow's raw milk. Total of 52 raw milk samples were collected from milk value chain points at Bishoftu and Akaki towns and analyzed. The results showed that the overall mean and standard deviation of physical and chemical quality of milk in the study areas for PH, freezing point, density, add water, acidity, fat, protein, SNF, total solid, lactose and ash contents of milk samples were 6.66±0.04, -0.55±0.03, 1.028±0.002, 2.80±3.60, 0.176±0.01, 3.60±0.53, 3.27±0.15, 7.78±0.41, 11.38±0.78, 3.93±0.25 and 0.62±0.05, respectively. The physical and chemical qualities of milk samples obtained from the study areas were significantly different ($P<0.05$). The data demonstrate that milk physical and chemical properties from the value chain of Bishoftu and Akaki had slightly fulfilled to the global and Ethiopia standard.

Key words: Raw milk · Lactose · Chemical properties · Protein · SNF

INTRODUCTION

Milk is a translucent white liquid, produced by the mammary glands of mammals with high nutritional value, providing the primary source of nutrition for young mammals before they are able to digest other types of food. Fresh milk considered as a complete diet because it contains the essential nutrients as lactose, fat, protein, mineral and vitamins in balanced ratio rather than the other foods [1]. Raw cow milk is composed of approximately 87.2 % water, 3.7% fat, 3.5% protein, 4.9% lactose 0.7% ash and has pH of 6.8 [2]. The smallholder dairy farming in many African countries, including Ethiopia, is important because it plays a significant role in ensuring food security and alleviation of poverty. Milk and milk products have important role in feeding the rural and urban population of Ethiopia owing to its high nutritional value. It is produced daily, sold for cash or readily pro-processed. It is a cash crop in the milk shed areas that enables families to buy other food stuffs and significantly contributing to the household food security [3].

To fulfill consumer demands, quality milk production is necessary. Quality milk means that the milk is free from harmful toxic substances, free from sediment and extraneous substances of good flavor with normal composition, adequate in keeping quality [4]. Milk if present in its natural form has high food value and supplies nutrients like good quality proteins, fat, carbohydrates, vitamins and minerals in significant amount. Besides its general need for human health, milk proteins also provide amino acids which are needed for proper growth of adults and infants [5]. Ethiopia's domestic milk production is above $3.0x10^9$ litres per annum and this is produced and processed by stallholder dairy farmers in urban and rural areas mostly in traditional way and usually supplied to the consumers in raw form [6].

This production and consumption trend will compel dairy industry to produce diverse milk products to suit the consumers' preferences and taste, which could be improved and attained through milk standardization [7]. However, prior to gearing into milk standardization it has become imperative to have basic empirical information on

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physicochemical components of milk produced by the farmers who owns the crossbreds. At this moment such information is limited. Therefore, the aim of this study was to assess the physical and compositional quality of cow's raw milk collected from different raw milk value chain points. The research work also claimed the government body to formulate standards and enforced it to make uniform compositions quality products.

MATERIALS AND METHODS

The study was conducted in smallholder dairy farms found in Bishoftu and Akaki Towns.

Milk Sample Collection: The study conducted a laboratory-based investigation aimed to assess quality of raw cow's milk collected from value chain pointsin Bishoftu and Akaki. 52 samples [40 milk producers (MP) who own crossbreed, 8 milk collectors (MC) and 4 milk processing plants (MPP)] were randomly selected. Before sampling the milk was thoroughly mixed and 50 ml of milk sample was collected aseptically into separate sterile bottles in the morning to be transported easily without any delay. The milk sample bottles were capped, labeled with a permanent marker and stored in an ice packed cool box and transported to the Ethiopian Meat and Dairy Industry development Institute laboratory for physical and chemical analyses on the same day.

Laboratory Analysis of Milk

Physical and Chemical Analysis of Raw Milk: Ekomilk analyzer (Model: Bulteh 2000, Bulgaria) reliable, automated multi-parameter milk analyzer providing rapid test results for chemical composition of milk (fat, protein, lactose and solid not fat) and physical characteristics (milk density, freezing point and added water) of the milk samples according to manufacturer's instructions. Based on ultrasonic technology, the instrument does not require any costly chemicals, caustic substances or reagents for testing. The pH of milk samples was measured electrometrically with a pH meter (Metrohm 704 pH meter).

Statistical Analysis: Data obtained from laboratory milk analysis was collaborated, then entered in Microsoft EXCEL and then exported to Statistical package for social scientists (SPSS), Version 20. Results were expressed as mean and standard deviation. The significant differences between means were calculated by a one-way analysis of variance (ANOVA) statistical analysis for comparison of the parameters variation at $P<0.05$.

RESULTS AND DISCUSSION

Raw Milk Physical Characteristics: The physical characteristics such as specific gravity, pH, freezing point and add water are important parameters in studying the physical properties of raw milk. Table 1and Table 2 show the various physical parameters of the different milk samples collected from the milk value chain points of Bishoftu and Akaki towns.

Added Water: In the study areas, an overall mean value for added water of 2.80±3.60 was recorded. Even though the results showed no significant variation ($P>0.05$), the mean value of added water was slightly different in the samples collected from milk collectors 4.76±5.85, followed by milk collected from milk processing plants and farmers 2.61±3.58 and 2.43±2.98, respectively. The average values of add water content in Bishoftu and Akaki were 3.58±3.91 and 1.20±2.18, respectively. The result showed significant variation ($p<0.05$) in the different locations. Overall mean of water add in the study areas was 2.80±3.60. This is similar with finding of Tsedey and Asrat [8] who reported water add content of cow's raw milk collected (2.83±0.99) and (2.55±0.99) in Hawasa and Yirgalem, respectively and higher than the results of (1.19±0.17) Dehinenet *et al.* [9] who reported for cow's raw milk quality under a smallholder production system in selected areas of Amhara and Oromia National Regional States, Ethiopia. It has been noticed that addition of water to normal whole milk was assumed to increase the quantity of milk [10]. However, the addition of water to milk not only reduces the nutritional value of milk but contaminated water may also pose a health risk [11]. The management practices, particularly the remains of the rinse water in the milk container prior to milking and addition of the wash water to the milk containers after the milking might have contributed to the presence of added water in milk.

Freezing Point of Milk: The freezing point of milk is an important indicator of the milk quality. Mean value and standard deviation of MP, MC and MPP were -0.55±0.02, -0.53±0.04 and -0.55±0.03, respectively. No significant differences ($P>0.05$) were found for freezing point of milk samples collected from different value chain points. Freezing point of milk in Bishoftu (-0.54±0.03) and Akaki (-0.56±0.02) was evaluated. The mean values of freezing point of milk samples collected from Bishoftu was significantly ($P<0.05$) high (Table 2). In this study, the overall mean value of freezing point was -0.55±0.03°C. The findings were comparable with the average milk freezing point reported by Zagorska and Ciprovica [12] who reported (-0.53±0.01) from raw milk collected in

Table 1: Summary of the results (mean±SD) of Physico-chemical parameters of raw milk collected from different value chain points of Bishoftu and Akaki towns, Ethiopia

	Milk value chain points			
Parameters	MP (N=40)	MC (N=8)	MPP (N=4)	Overall
PH %	6.66±0.05	6.66±0.01	6.66±0.01	6.66±0.04
Freezing point %	-0.55±0.02	-0.53±0.04	-0.55±0.03	-0.55±0.03
Density %	1.028±0.002	1.028+0.002	1.028±0.002	1.028±0.002
Add water %	2.43±2.98	4.76±5.85	2.61±3.58	2.80±3.60
Fat%	3.60±0.58	3.56±0.30	3.63±0.22	3.60±0.53
Protein %	3.28±0.14	3.19±0.20	3.28±0.15	3.27±0.15
SNF %	7.83±0.38	7.56±0.55	7.81±0.42	7.78±0.41
Total solid %	11.43±0.79	11.12±0.83	11.44±0.59	11.38±0.78
Lactose %	3.95±0.23	3.82±0.34	3.94±0.28	3.93±0.25
Ash%	0.63±0.05	0.59±0.04	0.60±0.00	0.62±0.05

MP =Milk collectors, MC= Milk Producers, MPP =Milk processing plants, N=number of samples, SNF=solid not fat

Table 2: Physico-Chemical properties of raw milk samples collected from Bishoftu and Akaki Towns, Ethiopia

Parameters	Bishoftu (N=35)	Akaki (N=17)	P-value
PH %	6.67±0.04	6.64±0.05	**
Freezing point %	-0.54±0.03	-0.56±0.02	**
Density %	1.028±0.002	1.029±0.002	**
Add water %	3.58±3.91	1.20±2.18	**
Fat%	3.51±0.54	3.78±0.46	NS
Protein %	3.23±0.16	3.34±0.12	**
SNF %	7.69±0.42	7.98±0.33	**
Total solid %	11.20±0.80	11.76±0.60	**
Lactose %	3.87±0.26	4.04±0.20	NS
Ash%	0.62±0.06	0.62±0.04	**

** = showed significant difference, NS= no significant difference N=number of samples

Lativa. The freezing point of milk could be affected by the freezing point of milk during cooling, or addition of wash water to the tank in most cases.

Specific Gravity: The mean and standard deviation of the specific gravity of raw milk samples collected from MP, MC and MPP were 1.028±0.002, 1.028+0.002 and 1.028±0.002 respectively (Table 1). Statistically it was found that there were no significant differences ($P < 0.05$) within the specific gravity of milk collected from the different milk value chain points. It was observed that specific gravity of milk obtained from Bishoftu (1.028±0.002) was higher than the specific gravity of milk obtained from Akaki (1.029±0.002). Significant differences ($P<0.05$) were observed for density between the Towns. The specific gravity of the current result of raw milk was slightly similar to that reported by Teklemichael *et al*. [13] in Dire Dawa town, Zelalem [14] who reported the specific gravity of milk samples tested was 1.028 and 1.029 for Holetta and Selale areas, respectively and Mahmood and Usman [15] who reported density of cow's raw milk (1.029± 0.0011.028) kg/liter was observed for the milk produced in Gujrat, Pakistan.

PH Content: PH is the parameter that determines the sample acidity and alkalinity. The average pH value was 6.66±0.04 with the areas sampled recording readings. The pH of all the milk samples collected from MP, MC and MPP were found to be 6.66±0.05, 6.66±0.01 and 6.66±0.01, respectively (Table 1). No significant variations were found for the parameter in all the milk samples in the different milk value chain points. The mean pH values of raw milk were 6.67±0.04 for Bishoftu and 6.64±0.05 for Akaki. The results showed significant variation ($P<0.05$) in the two towns. This is in line with the normal pH of fresh cow milk ranges from pH 6.6-6.8 reported by FAO [16].The pH value found in the current study was comparable with the findings in obtained from dairy farms in Dire Dawa town (6.627±0.135) [13]. PH values found in the sampled raw milk are in agreement with the findings of (6.76±0.51) Imran *et al.* [17] from various milk samples marketed in Pakistan and Enb *et al.* [18] who reported the pH value of (6.60±1.10) raw milk and heavy metals behavior during processing of milk in Egypt.

Raw Milk Chemical Parameters: The results of the experiment for chemical parameters of raw milk samples such as solids not fat (SNF), protein, lactose, fat, total solids (TS) and ash are shown in the Table 1 and Table 2.

Fat Content: The composition of milk samples collected from different channels is presented in Table 2. The mean value of fat content in milk samples collected from MP was 3.60±0.5 followed by MC and MPP (3.56±0.30 and

3.63±0.22, respectively). Statistical analysis showed that there were no significant differences (P>0.05) within the fat content of milk collected from different value chain points. The mean value of fat content in milk collected from Bishoftu (3.51±0.54) was lower than milk samples collected from Akaki (3.78±0.46), even though there was not significantly different (P>0.05). The overall mean of the fat content was 3.60±0.53.The result of fat content of this experiment is slightly similar with the finding of Jemila and Achenef [19] who reported the fat content of (3.70±0.89) raw milk produced in mid lactation of bred cross Holstein Friesian cows, North-western Ethiopia. But less than with reports of Teshome *et al*. [20] who found 4.28±0.05 fat from raw cow's milk produced and marketed in Shashemene town, Southern Ethiopia and Alganesh [21] who found 3.76 fat content from raw milk collected in peri-urban areas of Ejere, Walmera, Selale and Debre Birhan Districts of the central highlands of Ethiopia. The lower fat content of milk may be due to cows of that farm were high milk producing crossbreeds cows which reduces the fat content of the milk samples or water may be added with milk or partly skimming the milk or due to the fed more green forages. According to the Ethiopian standard agency, the minimum fat percent for whole milk should not be less than 3.5 percent [22]. Consequently, the average fat content (3.60±0.53) observed from the three values chain points milk samples were fulfilled the recommended standards.

Solid Not Fat (SNF): The average SNF content of raw milk samples collected from MP, MC and MPP are shown in the Table 2. The means and the standard deviation of SNF content of milk collected from MP, MC and MPP were 7.83±0.38, 7.56±0.55 and 7.78±0.41, respectively (Table 1). Statistical analysis showed that there were no significant differences within the SNF content of milk collected in the different milk value chain points. The average SNF content of raw milk samples collected from Bishoftu and Akaki towns were 7.69±0.42 and 7.98±0.33, respectively (Table 2). Statistically it was found that there were significantly different within the SNF of different types of raw milk samples collected from different Towns (Table 2). The results of this experimental analysis of SNF content of raw milk are in agreement with Estifanos *et al.* [23] who report the average SNF (7.98±0.98) of raw cow milk collected across the value chain in Harar milk shed. But different with the findings of Dehinnet *et al.* [9] who reported that the average SNF (8.44±0.72) of raw milk from selected areas of Amhara and Oromia National Regional States, Fikrineh *et al.* [24] found the average SNF percentage of raw milk of Adama town was 9.05±0.16 and with Debebe [25] who also reported the minimum (8.3±0.36) and maximum (8.7±0.36) SNF content of raw cow's milk obtained from street-vendors and milk producers in and around Addis Ababa, respectively. The standard for SNF content of whole cow milk is a minimum of 8.25% [26]. The average SNF content for the current study is below the recommended standards.

Total Solids (TS): The average total solid (TS) content of raw milk samples collected from MP, MC and MPP are shown in the (Table 1). The means and standard deviation of Total solids (TS) content of raw milk collected from MP, MC and MPP were 11.43±0.79, 11.12±0.83 and 11.44±0.59, respectively. Statistical analysis showed that there were no significant differences within the TS content of milk collected from the milk value chain points. The mean values of total solids in milk collected from Bishoftu (11.20±0.80) was significantly (P<0.05) lower than milk samples collected from Akaki (11.76±0.60) (Table 2). The average TS of raw milk samples collected from the value chain was11.38±0.78. This result is slightly comparable with the result of Teshome *et al.* [20] who found total solid in milk from Shashemene town (12.87±0.11) and also Mirzadeh *et al*. [27] reported total solids content in some dairy farms in Iran (12.57±0.69%). According to European Union established standards for total solids content of cow milk not to be less than 12.5% [28].Therefore, the current result of the average total solid content (11.38 %%) found from study areas were below the recommended standards. The lower TS content of collected raw milk samples may be due to addition of water with milk, lower fat content and this might also be due to the farmers' maintained high producing dairy cattle or high blood level crossbreed.

Ash Content: The average ash contents of raw milk samples collected from MP, MC and MPP were 0.63±0.05, 0.59±0.04 and 0.60±0.00 respectively (Table 1). Statistically it was found that there were no significant differences within the ash of different types of raw milk samples collected from different raw milk value chain points. The average ash content in milk samples collected from Bishoftu town (0.62±0.06) and Akaki (0.62±0.04) was similar. But statistically it was found that there were significant differences (P<0.05) within the ash content of different types of raw milk samples collected from the two locations (Table 2).The overall mean of ash content (0.62±0.05) found in the raw milk during this study is slightly similar with the findings of Imran *et al.* [17] and

Estifanos *et al.* [23] who observed that the means of ash in cow's raw milk collected from different locations were 0.64±0.07 and 0.68±0.16, respectively. But different from the finding of Teshome *et al.*[20] who reported (0.78±0.00) for the raw cow's milk collected from produced and marketed in Shashemene town, Southern Ethiopia.

Protein Content: The average protein contents of raw milk samples collected from MP, MC and MPP were 3.28±0.14, 3.19±0.20 and 3.28±0.15 respectively (Table 1). Statistical analysis showed that there was no significant difference ($p>0.05$) within the protein% of samples. The mean protein% in milk samples collected from Bishoftu (3.23±0.16) was slightly similar with Akaki town (3.34±0.12), although there was significant difference ($P <0.05$) between the two locations. The overall mean of the protein content was (3.27±0.15).This result is similar with reports of Debebe [25] who found protein content of milk 3.2±0.22from the milk producers in and around Addis Ababa City and Belay and Janssens [29] who reported the protein content (3.21±0.06) of raw milk samples collected from different urban dairy farms located in Jimma town. But it is slightly lower than Gurmessa *et al.* [30] who reported (3.94±0.07) for the raw cow's milk in Yabello District, Borana Zone. Dehinnent *et al*. [9] found that the mean value of protein content in milk collected from selected areas of Amhara and Oromia National Regional States (3.12±0.32%) which is lower than that of the current study. But, Teklemichael *et al.* [13] reported slightly higher result than protein contents (3.42%) for milk collected from dairy farms in Dire Dawa town and Fikrineh *et al.* [24] reported higher protein content (3.46±0.04) for milk samples collected from households rearing local and crossbred cows in Mid-Rift Valley of Ethiopia compared to the present study. According to Ethiopian standards Agency, the minimum percent protein content of whole milk should be 3.2 percent [22]. Hence, the average protein content for the current study is similar with the recommended standard of the nation.

Lactose: The average lactose contents of raw milk samples collected from MP, MC and MPP were 3.95±0.23, 3.82±0.34 and 3.94±0.28, respectively (Table 1). Statistical analysis showed that there was no significant difference ($p>0.05$) within the lactose content of different raw milk samples. The lactose of milk collected from Bishoftu (3.87±0.26) was lower than that of milk samples collected from Akaki (4.04±0.20), although no significant variations ($P>0.05$) were obtained between the two locations. Lactose content found in raw milk during this research work is less than the findings of Belay and Janssens [29] who reported the lactose content (4.34±0.13) of raw milk samples collected from different urban dairy farms located in Jimma town and Jemila and Achenef [19] who reported cow's raw milk (4.68±0.41) in bred cross Holstein Friesian cows, North-western Ethiopia. According to European Union quality standards for unprocessed whole milk, lactose content should not be less than 4.2% [28]. Therefore, the current average lactose content (3.93±0.25) found for the raw milk samples was below the recommended standards. The composition of milk can vary depending on breed of the animals and management practices influenced the milk composition [31].

CONCLUSIONS

This research was conducted in Bishoftu and Akaki towns with the aim of assessing the physical and chemical quality of raw milk collected from different value chain points. Generally, it can be concluded that the quality of cow's raw milk collected in both towns was similar and slightly fulfilled to the acceptable global and Ethiopia standards. This finding may be helpful for the concerned bodies to monitor the quality of the raw milk products in the marketing of the country. Farmers, milk collectors and processors need training in physical and chemical quality aspects of raw milk. Further investigations are carried out to examine other milk components in the milk value chain points in the study areas.

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