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RESEARCH ARTICLE

# Physicochemical quality of cow milk collected from different sources in Adewa, Central zone of Tigray, Ethiopia

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**Abstract:** The study was conducted in Adewa, central zone of Tigray Ethiopia, aimed to asess the physicochemical quality of raw cow milk collected from smallholders, cafeterias and local vendors. A total of seventy samples of raw cow milk were collected and analysed. All samples were collected using proportional random sampling method. The mean values for pH, specific gravity, titratable acidity, freazing point, Total solid , fat, Solid not fat, protein, ash and lactose contents of milk samples collected from smallholders and cafeterias were 6.640±0.03, 1.032±0.04, 0.165±0.01, -0.530±0.07, 12.84±0.05, 3.98 ±0.04, 8.86 ±0.01, 3.69 ±0.03, 0.58 ±0.06, 4.58 ±0.0 and 6.40 ±0.00, 1.026 ±0.00, 0.19±0.004, -0.48±0.009, 14.81±0.003, 4.63 ±0.005, 10.2±00, 4.24±0.005, 0.73±0.0013 and 5.20 ±0.002 respectively. In the case of milk samples collected from local vendors PH, specific gravity, titratable acidity, freezing point, Total solid, Solid not fat, Protin ash and lactos content were 6.27±0.007, 1.022±0.00, 0.28±0.006, -0.49±0.001, 14.1±0.002, 4.12±0.008, 9.94±0.003, 4.41±0.003 and 0.74±0.002 respectively. The study found that the chemical quality of samples collected from cafeterias and local vendors was significantly higher (P<0.05) than samples from small scale milk producers. However, the physicochemical quality of samples from all three sources was within the standard level, except for pH and titratable acidity in the samples from cafeterias and local vendors. This indicates that a need for improved physicochemical quality standards, providing training and education for small-scale milk producers, cafeterias, and local vendors on proper milk handling and storage practices, to enhancing the overall quality of milk in the region

**Keyword:** Physical; Chemical; Milk; Cow; Quality

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## Introduction

In developing countries like Ethiopia, dairy production plays a vital role in both rural and urban areas (Tegegne et al. 2013). Milk, a white liquid rich in protein, carbohydrates, fats, minerals, and vitamins, is a crucial component of the diet. It is obtained from various mammalian animals and consumed by humans (Pereira, 2014). Milk's nutritional richness and widespread availability make it an invaluable resource in improving health outcomes and promoting sustainable development.

The physiochemical composition of milk is a critical factor in determining its quality and suitability for producing processed milk products. Both the physical properties and chemical compositions of milk serve as indicators of its quality when it is hygienically normal (Kailasapathy, 2015). Freshly drawn milk exhibits variation in composition, structure, and properties. Even within the milk from a single milking of one cow, there can be differences (Alganesh et al. 2007). This variability underscores the importance of regular monitoring and assessment of milk quality, particularly in dairy production systems where factors such as breed, diet, milking practices, and animal health can influence milk composition.

Ensuring the production of quality milk is crucial to meet consumer demand and to facilitate the creation of high-quality dairy products. Quality milk is defined as milk that is free from pathogenic bacteria and harmful substances, has a good flavor, normal composition, adequate keeping quality, and low bacterial counts (Ahmedsham et al. 2018). It serves as the essential raw material for producing different dairy products(Saxena and Rai, 2013). However, In Ethiopia regions like Adwa district in Tigray, challenges exist in maintaining consistent milk quality due to variations in physicochemical composition caused by the addition of adulterants and the absence of quality measurement standards. In the study area Adwa district, where milk production primarily occurs through informal marketing systems, and there is no established quality control system between producers and consumers for ensuring milk quality. To address this gap, studies such as the one conducted in Adewa central zone of Tigray, Ethiopia, are essential. The objective of this studies were to compare the physical properties and chemical composition of cow milk collected from different sources. By addressing the challenges related to milk quality in regions in Adwa district was essential for the sustainable growth of the dairy industry and the satisfaction of consumer demand for safe and nutritious dairy products.

## Materials and Methods

### Descriptions of the study area

The study was carried out in Adewa district which is located in central zone of Tigray, Ethiopia. Geographicaly location of Adwa district, lie between 380 53'55"E to 380 57' 30" E longitude and 140 08' 43" N to 140 11' 47 "North latitude. The annual mean rainfall ranges from 600 to 850 mm. The annual average temperature ranged from 12 $^{0}$C to 27 $^{0}$C.

### Research Design

The study involved laboratory based investigation aimed to investigate the Quality of milk in the basis of physio-chemical Characterstics of raw cow milk collect from small-scale milk producers, local venders and cafeterias in Adewa central zone of Tigray. A total of seventy raw milk samples was collected in morning and afternoon from local venders, Cafeterias and small-scale milk producers from selected four kebeles based on their dairy potential.

### Data sources and collection procedures

A total of seventy samples of raw cow milk was collected in morning and afternoon from three different sampling point's namely local venders, Cafeterias and small scale milk producers from purposefully selected four kebeles. Fifteen local venders, twenty cafeterias and thirty five small scale local milk producers based on the interview were selected at each kebele. All the samples was collected using proportional random sampling methods. During the collection time raw milk samples were aseptically collected from the bulk milk container of producers, local venders and cafeterias and small scale milk producers and placed into sterile bottles then samples were labeled and transported to Mekelle University Animal Production and Technology Laboratory in an icebox at 4°C for physio-chemical analysis.

### Physico-chemical analysis

Analyses of physicochemical properties of cow milk were done at Mekelle University Animal Production and Technology Laboratory using a Lacto scan (model number SL30 and brand name Sri Balaji Made in India Instruments) to determine the percentage composition added water, specific gravity/density, titratable acidity/lactic acid, freezing points, pH, lactose, protein, fat, ash and total solid(ST).

### SNF (Solid not fat)

To know the amount of this Solids-not-fat (SNF) content was determined by subtracting percent fat from TS present used by this formula to calculate the following formula: Solids-not-fat = Total solids – fat

### Statistical analysis

The data collected from physiochemical properties of milk among small scale milk producers, local venders and cafeterias was analyzed by using analysis of variance (ANOVA) used the General Linear Model (GLM) procedure of (SAS, 2012). The sample mean were compared using Duncan Multiple Range Test Mean (DMRT) tests.

## Result and Discussion

### Physical quality of cow milk

Milk in normal state has unique physic-chemical properties, which are used as quality indicators. It appears that the study conducted in Adewa observed differences in the temperature of raw milk samples collected from various sources, including small-scale milk producers, cafeterias, and local vendors Table 1. The findings suggest that the mean temperature of the milk samples varied significantly ($P < 0.05$) among these sources, with milk from small-scale producers having a higher temperature compared to milk from cafeterias and local vendors. The higher temperature of milk from small-scale producers could be attributed to variations in milk handling equipment and techniques. The study suggests that the lack of cooling systems and insufficient use of refrigerators among milk producers in the area contributed to the elevated temperature of the milk samples collected (Eshetu et al. 2019). Proper milk handling practices and adequate cooling systems to maintain the quality of raw milk, as temperature can impact its physicochemical properties and overall quality.

The PH values of milk samples collected from small scale milk producers were significantly higher than cafeterias and local vendors's sample (Table1). Milk pH is used as an indication of milk hygiene and it usually ranges between d"6.5 and e"6.7. The normal PH of milk was an important indicator of growth of bacteria in the milk sample. Cooling of milk reduces the risk of growth of bacteria while high milk temperature considered as favorable for the growth of bacteria in milk (Moatsou and Moschopoulou, 2014). According to the results obtained in the present study, pH of milk samples from cafeterias (6.40) and local vendorss (6.27) were not within the normal ranges. In general, the pH of milk samples collected from cafeterias and local vendors was significantly lower ($P < 0.05$) than the pH of milk obtained from small scale milk producers (Table1).

The specific gravity of raw milk samples collected from different sources in Adewa was measured, with the following values obtained: 1.026 for cafeterias, 1.022 for local vendors, and 1.032 for small-scale milk producers. These values exhibited a statistically significant difference among the sources, as indicated in Table 1. according to a study by Janštová et al. (2011), the specific gravity of normal milk typically ranges from 1.028 to 1.033 grams per milliliter. In the current study, the specific gravity of milk samples from small-scale milk producers was within this range and comparable to findings by (Tamime, 2009). Furthermore, O'Connor (1993), suggests that a higher specific gravity value may indicate the skimming off of fat from the milk, while a lower value than the normal range could suggest the addition of water.Based on this information, the specific gravity measurements in the Adewa study indicate variations in the composition of raw milk samples from different sources, potentially reflecting differences in milk quality, such as fat content or water adulteration. These findings underscore the importance of monitoring and regulating milk quality to ensure consumer safety and trust in dairy products.

The titratable acidity of raw milk samples collected from various sources in Adewa was analyzed, revealing significant differences among samples from small-scale milk producers, cafeterias, and local vendors, as indicated in Table 1.Milk samples obtained from cafeterias and local vendors exhibited a titratable acidity value exceeding 0.18%, suggesting prolonged exposure to room temperature and poor handling practices prior to sale and consumption. Additionally, these samples showed significantly higher titratable acidity compared to those from small-scale milk producers. The elevated titratable acidity in milk from cafeterias and local vendors may be attributed to bacterial growth and multiplication during milk transportation and storage before sale. This observation aligns with the findings of Yilma and Faye (2006), who reported even higher titratable acidity (0.27%) in milk samples collected from dairy shops in the central highlands of Ethiopia. These results emphasize the importance of proper milk handling and storage practices to maintain milk quality and minimize bacterial contamination, ultimately ensuring consumer safety and satisfaction with dairy products.

Freezing point of milk is usually in the range of -0,512 and -0,550 with an average of -0,522. The freezing point of milk is a physicochemical property that is closely correlated with several other key characteristics of milk. As the concentration of total solids increases, the freezing point of milk decreases. This is because dissolved solids, such as lactose, proteins, and minerals, lower the freezing point of a solution. Therefore, milk with higher total solids content typically has a lower freezing point. Proteins, particularly casein and whey proteins, contribute to the total solids content of milk and can lower the freezing point. Additionally, changes in protein composition or denaturation

**Table 1:** Physical properties of cow milk obtained from small scale milk producers, cafeterias and local vendors

| Physical Qualities | Milk Source | | | |
|---|---|---|---|---|
| | Small scale milk producers (n=35) | Cafeterias (n=20) | Local vendor (n=15) | Overall Mean |
| Temp. ($^0$C) | 28.500$^a$±0.06 | 26.6$^b$ ±0. 00 | 24.5$^c$±0.00 | 26.530±0.03 |
| pH value | 6.640$^a$±0.03 | 6.40$^b$ ±0. 00 | 6.27$^c$ ±0. 007 | 6.440±0.03 |
| SG | 1.032$^a$±0.04 | 1.026$^b$ ±0. 00 | 1.022$^c$ ±0. 00 | 1.028±0.03 |
| TA (%LA) | 0.165$^b$±0.01 | 0.19$^a$±0. 004 | 0.28$^a$±0. 006 | 0.121±0.05 |
| FP | -0.530$^b$±0.07 | -0.48$^a$±0. 009 | -0.49$^a$±0. 001 | -0.515±0.00 |

Means followed by different superscript letters within a row are significantly different (P < 0.05), Temp. = Temperature, SG = Specific gravity, TA= Titratable acidity, FP= Freezing point and n= number of samples

**Table 2:** Chemical properties of cow milk obtained from small scale milk producers cafeterias and local vendors

| Chemical composition | Milk Source | | | |
|---|---|---|---|---|
| | Small scale milk (producers) (n=35) | Cafeterias (n=20) | Local vendor (n=15) | Over all Mean |
| TS (%) | 12.84$^c$ ±0. 05 | 14.81$^a$±0. 003 | 14.1±0.002$^b$ | 13.67±0.05 |
| Fat (%) | 3.98$^{bb}$ ±0. 04 | 4.63$^{aa}$ ±0. 005 | 4.12$^{ab}$ ±0. 008 | 4.20±0.055 |
| SNF (%) | 8.86$^b$ ±0. 01 | 10.2$^{aa}$±00 | 9.94$^a$±0. 003 | 9.46±0.04 |
| Protein (%) | 3.69$^b$ ±0. 03 | 4.24$^{aa}$±0. 005 | 4.41$^a$ ±0. 003 | 4.0±0.05 |
| Salt (%) | 0.58$^b$ ±0. 06 | 0.73$^{aa}$±0. 0013 | 0.74$^a$ ±0. 002 | 0.66±0.07 |
| Lactose (%) | 4.58$^b$ ±0. 01 | 5.20$^{aa}$ ±0. 002 | 4.78$^a$ ±0. 0028 | 4.80±0.015 |

Means followed by different superscript letters within a row are significantly different (P < 0.05), TS = Total solid, SNF= Solid Not-Fat and n= number of samples may impact the freezing point of milk. Changes in acidity levels, indicated by pH and titratable acidity, can also influence the freezing point of milk. Increased acidity, resulting from microbial spoilage or other factors, can lead to a lower freezing point due to the presence of acidic compounds in the milk (Zagorska and Ciprovica, 2013). Monitoring the freezing point of milk can provide valuable information about its quality, freshness, and suitability for various dairy processing applications The mean value the current study milk sample freezing point of the study area was -0.515±0.00 this means the milk collected from the milk is within the standard of freezing point of milk.

**Chemical Composition of cow milk**

Protein content of milk obtained from small scale milk producers, cafeterias and local vendors was 3.69±0.03, 4.24±0.005 and 4.41±0.003, respectively (Table2). There was difference (P>0.05) among milk samples in the three areas. This might be due to the combination of the samples from different sources. The average protein content of raw milk obtained from small scale milk producers, cafeterias and local vendors was higher than the earlier findings of Terfa (2014), who reported a protein content of 3.48% for milk produced in dairy farms. The overall mean protein content 4.0±0.05 percent obtained in the current study was higher than the protein content of 3.1 percent reported for Zebu cows' milk (O'Connor, 1995). Correspondingly, Negash et al. (2012), reported lower protein content (3.46±0.04%) for milk samples collected from householdss producing local and crossbred cows. According to European Union quality standards the fresh whole milk, total protein content should not be less than 2.9%. Therefore, the average protein content (4.0±0.05) observed from three areas was within the recommended standards.

There was significant difference (P > 0.05) in fat content observed among the samples collected from three study areas (Table2). The fat content was significantly affected by the factors like feed, parity, breed and stage of lactation. Fat content was highest in cafeterias (4.63±0.005) than in local venders (4.12 ±0.008) and small scale milk producers (3.98±0.04) (Table2). The mean value of the three areas (4.20±0.055) were greater than the earlier findings of Janštová et al. (2011), who reported a fat content of 3.79±0.18% for milk produced in dairy farms. On the other hand, the average fat content fresh (raw) whole cow milk obtained in this study (4.20±0.055) was lower than the earlier finding of Ketema et al. (2018) who reported a fat content of 5.46 ±0.51% for milk samples collected from Walmera District of Oromia Region household producing local cows. According to Teklemichael (2012) The Food and Drug Administration (FDA) require not less than 3.25% milk fat for fluid whole milk. According to Terfa (2014), consequently, the average fat content (4.0±0.05) observed from three areas was within the recommended standards. Fat of milk is unquestionably the most valuable constituent of milk. Milk having a fair amount of fat is more valuable as a food than milk which is poor in fat (Bishoftu, 2016).

The Total Solids (TS) component of milk is a crucial indicator of its overall quality and nutritional value. TS represents all the non-water components present in milk, including proteins, fats, lactose, minerals, and other solids Kennelly et al. (2000) and Bezie (2019). In the current study the data indicate the presence of the significant differences (P < 0.05) in the SNF content among milk samples collected from small scale milk producer's cafeterias and local vendors. The SNF content of milk collected from small scale milk producers cafeterias and local vendors were 8.86±0.01and 10.2±0.00 and 9.94±0.003 (Table 2). The difference observed in the SNF content of milk could be due to the difference in the feeding practice, season, milking method and lactation period (Lingathurai et al. 2009). The SNF content the three areas (9.46±0.04) obtained in the current study was lower than the result obtained by Nigussie and Seifu (2007) who reported SNF contents of 10.7% for cows' milk in Kombolcha woreda. However, this value is greater than the finding reported by Teklemichael (2012) and Debebe (2010) for milk obtained from dairy farms (8.75%) in Dire Dawa town and 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. According to European Union quality standard the raw whole cow milk SNF content should not be less than 8.5% (Tamime, 2009). Accordingly, the average SNF content (9.46±0.04) observed for three milk samples were within the recommended standard. This suggests that the milk samples analyzed in this study possess adequate total solids content, indicating good nutritional quality. Higher TS content indicates a greater concentration of essential nutrients, such as proteins, fats, and minerals, making the milk more nutritious (Kittivachra et al. 2006). Dairy processors often prefer milk with specific TS levels for different products. For example, milk with higher TS content is preferred for cheese-making, as it yields higher cheese yields and better texture. Conversely, milk with lower TS content may be more suitable for fluid milk products like pasteurized milk or flavored milk (Abd El-Gawad and Ahmed, 2011). The TS content significantly impacts the flavor and texture of milk. enhances the sensory experience of consuming milk and is often preferred by consumers (Yayota et al. 2013). Monitoring and optimizing TS content are essential for ensuring the production of high-quality milk that meets consumer preferences and regulatory standards.

The salt content of milk, also known as the mineral content, is an important aspect of its overall composition and nutritional value (Zamberlin et al. 2012). In your study, the overall mean salt content obtained was reported as 0.66±0.07. Additionally, you observed that milk samples collected from local vendor and cafeterias had significantly higher salt content compared to samples obtained from small-scale milk producers.Overall, while the salt content of cow's milk typically remains relatively constant within a certain range (around 0.7% to 0.8%), variations can occur due to factors such as breed, stage of lactation, feed, interval between milkings, completeness of milking, and the age and health status of milking cows (O'Connor, 1995). Understanding these factors is important for interpreting variations in milk composition and ensuring the production of high-quality milk for consumption and processing into dairy products.

The lactose content of milk is an essential component that contributes to its taste, texture, and nutritional value (Pereira, 2014) and (Guetouache et al. 2014). In this study, observed that the lactose content was significantly higher in milk from cafeterias compared to milk from small-scale milk producers and local vendors. Lactose content was significantly higher ($P<0.05$) in cafeterias than milk from small scale milk producers and local vendors (Table 2). Differences in storage conditions between cafeterias and other sources may impact lactose content. Cafeterias may have different storage practices or conditions that influence the microbial activity and enzymatic processes occurring in milk, leading to variations in lactose content. The average lactose content of the three areas was 4.80±0.015% which was higher than the result obtained by Teklemichael (2012), who reported lactose contents of 4.43±0.06% for cows' milk in Shashemene town southern Ethiopia. According to European Union quality standard for unprocessed cow milk whole milk lactose content should not be less than 4.2%. There for average lactose 4.80±0.015% content observed from the three milk samples were within the recommended standard. Regarding the comparison with previous studies, this findings show that the average lactose content (4.80±0.015%) from the three milk sources was higher than the results reported by Teklemichael (2012) for cows' milk in Shashemene town, southern Ethiopia. This difference could be attributed to various factors such as breed differences, feeding practices, and environmental conditions between the study areas. The average lactose content observed in this study met the European Union quality standard for unprocessed cow milk, which specifies that the whole milk lactose content should not be less than 4.2%. This suggests that the milk samples analyzed in your study meet the recommended standard for lactose content, indicating good quality and nutritional value.

## Conclusion

The study on the physicochemical and chemical composition of cow milk from different sources in Adewa, Tigray, Ethiopia, provided valuable insights into the quality of milk available in the region. Generally, variations were observed in the physicochemical of cow milk from different sources of the milk samples met quality standards. However, differences among sources are the importance of proper milk handling, storage, and management practices to ensure consistent quality and safety of milk for consumers.

## Conflicts of interest

The authors declare that they have no conflict of interest.

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