



**PHYSICOCHEMICAL PROPERTIES OF RAW AND FERMENTED COW MILK
PRODUCED BY SMALLHOLDER FARMERS IN
BAUCHI METROPOLIS, NIGERIA**

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ABSTRACT

The study was carried out to assess the physicochemical properties of raw and fermented cow milk produced by smallholder farmers in Bauchi Metropolis, Nigeria. The key indicators of milk quality used consisted of moisture, fat, protein, lactose, and ash content. Milk samples from five different locations (Lushi, Bayara, Tabuli, Yayire, and Dandango) were analyzed for both raw and fermented states. Raw milk samples exhibited variability in moisture content, with Dandango recording the highest value (80.50%) and Bayara the lowest (73.78%). Solid non-fat content and titratable acidity remained stable across locations, while fat and protein content showed non-significant difference. These variations reflect the impact of environmental factors, feed quality, and milking practices on milk composition. Fermented milk samples revealed a significant differences in moisture and solid non-fat (SNF) content among locations. Yayire recorded the highest moisture content (83.08%), while Bayara had the highest SNF (8.18%), indicating a better nutrient retention in fermentation. The titratable acidity remained consistent, highlighting similar fermentation processes across the study sites. Fat content in fermented milk was generally lower compared to raw milk, with Lushi exhibiting a slightly higher fat concentration. Protein and lactose content did not differ significantly, with Lushi showing the highest protein content (9.25%), likely due to better preservation during fermentation. The study highlights the role of local environmental conditions, traditional milk processing methods, and feeding practices in shaping the physicochemical properties of milk. The results emphasizes the importance of improving milk production and processing techniques among smallholder farmers to ensure better quality and safety. This can lead to enhanced nutritional value and extended shelf life, contributing to public health and economic development in the dairy sector.

Key words: Physicochemical properties, raw cow milk, fermented milk, smallholder farmers

INTRODUCTION

The quality of milk, both raw and fermented, is of paramount importance for public health and the dairy industry. Key indicators of milk's safety, nutritional value, and suitability for processing are its physicochemical properties and microbial quality. Smallholder farmers, who play a crucial role in milk production in many developing regions, often face challenges in maintaining these quality standards due to limited resources and access to advanced technologies (Yusuf & Malomo, 2017). Raw cow milk is a primary source of essential nutrients such as proteins, fats, vitamins, and minerals. However, it is also highly susceptible to microbial contamination, which can lead to foodborne illnesses. The physicochemical properties of raw milk, including pH, fat content, protein content, and lactose levels, significantly influence its quality and shelf life. Ensuring the microbial quality of raw milk involves stringent hygiene practices during milking, storage, and transportation (Adetunji & Odetokun, 2021).



Fermentation is a traditional method of preserving milk and enhancing its nutritional and sensory attributes. Fermented milk products, such as yogurt, kefir, and traditional African fermented milks, are rich in probiotics that contribute to gut health. The fermentation process involves the action of specific lactic acid bacteria, which transform lactose into lactic acid, lowering the pH and thus inhibiting the growth of pathogenic microorganisms. The physicochemical changes during fermentation, such as increased acidity and altered texture, are crucial for the quality and acceptability of the final product (Okpalugo *et al.*, 2018). In many developing countries, smallholder farmers are the backbone of the dairy sector. These farmers typically operate on a small scale, with limited resources for advanced milk production and processing techniques. Despite these challenges, they contribute significantly to local economies and food security. Understanding the physicochemical properties and microbial quality of milk produced by smallholder farmers is essential for developing strategies to improve milk safety and quality (Omotosho & Ayoola, 2020). Milk possesses a complex biochemical composition and a high water activity. Its nutritional richness makes raw milk an ideal medium for microbial growth, which can degrade its quality and shelf life. Meeting consumer demand for safe, high-quality milk places significant responsibility on dairy producers, retailers, and manufacturers (Degraaf *et al.*, 2019; Mennane *et al.*, 2017). Adverse environmental conditions significantly impact milk and milk product quality. In hot and humid climates, raw milk easily ferments and spoils during storage unless refrigerated or preserved. However, such facilities are often unavailable in rural areas where dairy infrastructure and cooling systems are lacking (Teshome *et al.*, 2018). According to Muriuki *et al.* (2021), much of the milk produced outside urban centers is processed into dairy products using traditional household-level technologies. In the study area, traditional methods prevail for milk production, processing, and storage, resulting in substandard quality products due to inadequate infrastructure like refrigeration and clean water, and limited knowledge of hygienic milk handling. Despite milk production being vital to the livelihoods in the Bauchi community, there is a notable absence of published data on the physicochemical properties of raw cow's milk produced by smallholder farmers.

MATERIALS AND METHODS

Area of the Study

The study was conducted in Bauchi Metropolis, located in Bauchi State, Nigeria. The state is located between latitudes 10°17' North and longitudes 9° 49' East at an altitude of 690.2m above the sea level. Specifically, the research focused on smallholder dairy farmers from five distinct locations within the metropolis: Lushi, Bayara, Tabuli, Yayire and Dandango (Abubakar and Burriah, 2013).

Sampling Technique and Sample Size

A total of 50 milk samples were collected for this study, with an equal distribution between raw and fermented milk. Each sample was collected in sterile containers and transported under refrigerated conditions to minimize changes in microbial quality and physicochemical properties.

Sample Analysis

The collected milk samples were analyzed at the Biochemistry Laboratory of Abubakar Tafawa Balewa University Bauchi. The analysis focused on both physicochemical properties and



Physicochemical Analysis

The physicochemical properties of the milk samples were assessed using several parameters such as moisture content, solid non-fat (SNF), titratable acidity, fat content, protein content, lactose content and ash content

Statistical Analysis

Data from the physicochemical properties were subjected to analysis of variance (ANOVA) using SPSS statistical software and significantly different treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Physicochemical Properties of Raw Milk

Table 1 shows result of the physicochemical properties of raw milk samples collected from different locations. The result revealed that, moisture content ranges from 73.78% in Bayara to 80.50% in Dandango, showing significant variation ($P < 0.05$) across the locations. The result further indicated that Dandango had the highest moisture content (80.50%), while Bayara had the lowest (73.78%). This variability could be influenced by factors such as feed quality, hydration of animals, and milking practices. Higher moisture content is generally associated with lower solid content, as seen in Dandango's relatively lower solid non-fat (6.20%) compared to other locations. Similar results were reported by Afolabi *et al.* (2016) and Olaleye *et al.* (2018), where geographic and climatic conditions significantly affected milk moisture levels. The solid non-fat content ranges from 5.10% in Yayire to 7.73% in Lushi. Although no significant difference was observed, the SNF is an important indicator of milk's nutritive value. Lushi recorded the highest SNF, which might suggest better feeding practices or genetics in that region. Previous findings by Jafari *et al.* (2020) highlighted a similar trends where SNF content varied depending on the diet and health of the animals. The titratable acidity remained consistent across locations, ranging between 0.002% in Lushi and 0.003% in Yayire and Dandango. While the values did not significantly differ, acidity is an indicator of milk freshness and microbial activity. Milk with higher acidity tends to spoil faster. The relatively low titratable acidity values across the regions indicate good milk quality, aligning with the findings of Adewuyi *et al.* (2019), who recorded similar low acidity levels in fresh raw milk samples.

Fat content ranges from 2.20% in Lushi to 2.80% in Dandango and Bayara, with no significant difference observed. Fat content is crucial for determining the energy value of milk, and its variability can be influenced by breed, feed, and lactation stage. The findings are consistent with those of Asabe *et al.* (2017), who also reported no significant differences in milk fat content across different geographic regions in Nigeria. The slightly higher fat content in Bayara and Dandango could be attributed to differences in feed quality, as regions with better grazing or supplemented diets typically yield higher milk fat content. Protein content varied from 7.09% in Yayire to 8.51% in Lushi, with no significant difference. Milk protein is a key factor in determining its nutritive value and quality for dairy production. Lushi, having the highest protein content (8.51%), may reflect better nutrition or breed differences in this region, similar to findings by Yilma *et al.* (2021) that showed variations in milk protein levels based on geographical location and feeding systems. Lactose content showed minimal variation, ranging from 11.98% in Lushi to 13.01% in Yayire, with no significant difference. Lactose is essential for milk's sweetness and influences its digestibility. The values align with studies by Tesfaye *et al.* (2015), who reported similar lactose percentages in raw milk samples across various regions, indicating that lactose content tends to remain stable despite environmental and management differences. Ash content, which represents the



mineral content of milk, ranged from 4.83% in Lushi to 6.75% in Dandango. Although not statistically significant, the higher ash content in Dandango may indicate a richer mineral profile, possibly due to variations in soil quality and water supply in that region. This is consistent with reports by Getachew *et al.* (2020), where ash content in milk was influenced by the mineral composition of the animals' diet and water sources.

Table 1: Physicochemical Analysis of Raw Milk from Different Locations

Parameter (%)	Lushi	Bayara	Tabuli	Yayire	Dandango	SEM
Moisture Content	79.10 ^{ab}	73.78 ^c	77.65 ^b	75.25 ^{bc}	80.50 ^a	0.98*
Solid Non-Fat	7.73	7.10	7.68	5.10	6.20	0.51 ^{NS}
Titrateable Acidity	0.002	0.0025	0.0025	0.003	0.003	0.20 ^{NS}
Fat Content	2.20	2.78	2.30	2.25	2.80	1.08 ^{NS}
Protein Content	8.51	8.12	7.51	7.09	7.81	2.06 ^{NS}
Lactose Content	11.98	12.53	12.06	13.01	12.25	2.31 ^{NS}
Ash Content	4.83	6.15	5.40	5.75	6.75	1.97 ^{NS}

Means followed by the same letter in a row are statistically similar by DMRT, NS = not significant, * = significant @ 0.05 probability level

Physicochemical Properties of Fermented Milk

Table 2 shows result of the physicochemical properties of fermented milk samples from different locations. The result indicated that, moisture content in fermented milk samples ranges from 74.58% in Dandango to 83.08% in Yayire, showing significant differences ($P < 0.05$) among the locations. Yayire had the highest moisture content, possibly indicating longer fermentation or different microbial activity leading to higher water retention. The lowest moisture content in Dandango (74.58%) may be due to a shorter fermentation period or different environmental conditions. These findings align with the studies of Abegaz *et al.* (2018) and Ogundola *et al.* (2018), who reported that fermentation and environmental factors like humidity influence moisture content in traditionally fermented dairy products. The SNF content varied significantly ($P < 0.05$) among locations, ranging from 5.78% in Lushi to 8.18% in Bayara. Bayara's fermented milk had the highest SNF, which suggests better retention of solids during fermentation, possibly due to differences in milk composition prior to fermentation. Lushi's lower SNF could be attributed to higher moisture content diluting the solids. The SNF values are consistent with findings by Nout *et al.* (2015), who noted that solid non-fat content in fermented milk is influenced by the initial milk quality and the fermentation process. Titrateable acidity showed no significant difference ($p > 0.05$) across locations, ranging from 0.0025% to 0.003%. This suggests that the fermentation processes in all locations were consistent in terms of acidity development. Acidity levels are critical in determining the sensory properties and shelf life of fermented milk. The relatively low acidity values observed in this study reflect those found in similar fermented dairy products studied by Ayeni *et al.* (2021), who noted that traditional fermentation techniques often result in mildly acidic fermented milk.

Fat content ranges from 2.15% in Yayire to 3.36% in Lushi, with no significant differences ($P > 0.05$). The fat content in fermented milk is typically lower than in raw milk due to fat breakdown during fermentation. Lushi's higher fat content may indicate less



microbial degradation of fat during fermentation, while Yayire's lower fat content could be due to more intensive fermentation activity. These results are in line with studies by Abd El-Salam and El-Shibiny (2021), who reported that fat content in fermented milk is influenced by both the fermentation process and milk source. The protein content ranged from 6.61% in Bayara to 9.25% in Lushi, with no significant difference ($P > 0.05$). Fermented milk from Lushi had the highest protein content, which might suggest that fermentation processes there preserved protein better or that the milk initially had a higher protein content. Protein content is a key quality attribute in fermented milk, affecting texture and nutritional value. These findings align with those of Walshe *et al.* (2022), who found similar protein content variation across different regions in fermented milk. Lactose content ranges from 11.68% in Bayara to 12.91% in Dandango, with no significant difference. Fermentation typically reduces lactose content as lactic acid bacteria convert lactose into lactic acid. The similar lactose levels across locations indicate comparable fermentation dynamics. These results support the findings of Khedid *et al.* (2019), who observed that the lactose content in fermented dairy products tends to stabilize once fermentation is complete. Ash content, which reflects the mineral content of the milk, ranged from 4.90% in Dandango to 6.05% in Tabuli, with no significant differences. Ash content tends to be influenced by the mineral composition of the milk and the type of fermentation. The higher ash content in Tabuli suggests a richer mineral profile, possibly due to the quality of the water or soil in the region. These findings align with similar studies by Jandal *et al.* (2020), who noted that geographic and environmental factors influence the mineral content in fermented milk products.

Table 2: Physicochemical Parameters of Fermented Milk from Different Locations

Parameter (%)	Lushi	Bayara	Tabuli	Yayire	Dandango	SEM
Moisture Content	78.65 ^b	76.88 ^{bc}	77.85 ^{bc}	83.08 ^a	74.58 ^c	0.82*
Solid Non-Fat	5.78 ^c	8.18 ^a	7.20 ^b	7.55 ^b	7.63 ^b	0.28*
Titrateable Acidity	0.0025	0.0025	0.003	0.003	0.0025	0.02 ^{NS}
Fat Content	3.36	2.28	2.50	2.15	3.05	1.02 ^{NS}
Protein Content	9.25	6.61	8.55	6.65	8.97	2.10 ^{NS}
Lactose Content	12.25	11.68	11.87	12.25	12.91	2.83 ^{NS}
Ash Content	5.68	5.75	6.05	5.78	4.90	1.89 ^{NS}

Means followed by the same letter in a row are statistically similar by DMRT, NS = not significant, * = significant @ 0.05 probability level

CONCLUSION AND RECOMMENDATIONS

The study analyzed the physicochemical properties of raw and fermented milk from five locations. Significant variations were observed in moisture content, solid non-fat and protein content across the regions. These differences are likely influenced by environmental conditions, milk handling practices, and fermentation processes. The study found that both raw and fermented milk generally met satisfactory standards for fat, lactose, and ash content, with stable titrateable acidity observed during fermentation. The findings suggest that geographic factors play a key role in milk quality, emphasizing the importance of consistent dairy handling and processing practices to maintain product quality. Fermentation showed notable effects on the physicochemical properties of milk, especially in moisture content and acidity, which underscores the need for standardized processes across locations to ensure product uniformity. These results provide insights into milk production in Nigeria and



highlight areas for improvement in dairy processing. To improve dairy quality, recommendations include standardizing milk processing and fermentation techniques, implementing routine quality checks, promoting hygienic milk production, and supporting smallholder farmers with better technology and training. Further research on regional variations in milk composition will help tailor solutions to specific locations, enhancing both the quality and efficiency of dairy production in the country.

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