



Evaluation of Physicochemical Properties of Traditionally Heat-treated Fresh Milk Sold in Local Restaurants of Bujumbura city, Burundi

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Abstract: A study was done to evaluate the physical property and chemical composition of traditionally heated milk sold in local restaurants of Bujumbura city. Thirty milk samples were collected from three communes of Bujumbura City for physical and chemical composition analysis. The physical parameters were pH, density, freezing point and chemical composition concerned non-fat solids, proteins, fat, and lactose. As results, fat content was $2.922 \pm 0.863\%$, with 70% of samples below the EAC standard, pH was 5.253 ± 0.249 , lower than typical whole milk values, non-fat solids were compliant at $8.522 \pm 0.968\%$, protein and lactose levels averaged $3.117 \pm 0.359\%$ and $4.676 \pm 0.537\%$, respectively. While density measured 1.029 ± 0.004 g/ml, with 33.3% of samples falling below standard levels, the freezing point was $-0.5393 \pm 0.067^\circ\text{C}$, compliant with standards. Milk adulteration was notably found with an added water of $3.614 \pm 6.057\%$. The study will enhance the understanding of quality standards among local milk suppliers and contribute to improvements that ensure better consumer trust and safety.

Keywords: Heat-treated cow milk, Fresh Milk, Quality, Local Restaurant, Physicochemical properties, Bujumbura city, Burundi.

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1.0 Introduction

Milk is a cornerstone of human nutrition and a versatile ingredient used globally in various culinary and industrial applications (Hansen, 1974). It constitutes a source of macronutrients with significant amounts of dietary energy and essential fats and proteins, as well as important micronutrients, such as calcium, vitamin B12, riboflavin (vitamin B2), and vitamin A, which are sometimes supplemented further through fortification (Ecker & Pauw, 2024). For this reason, dairy consumption is widely promoted to improve the nutritional status of individuals and populations (Burgess, 2014).

The composition of milk is influenced by factors such as animal species, diet, lactation period, and environmental conditions (Taylor and Francis Group, 2016). Assessing the physicochemical properties of milk, including fat content, protein levels, total solids,

and pH, is essential for evaluating its quality, safety, and suitability for consumption or further processing (Albert et al., 2024; Imran et al., 2008).

In Burundi, milk produced locally comes from extensive or semi-intensive production systems. Its distribution system is either formal or informal. However informal distribution takes a large area (Bitama & Ndayishimiye, 2023; Michael, 2016). Most of farmers from rural areas sell their milk in town including Bujumbura city, the main milk market (Ouma & Godfrey, 2020) and potential customer in terms of consumption of dairy products.

A large group of people in Burundi consume raw and traditionally heat-treated milk than other forms of milk (Albert, 2018) and local restaurants serve milk directly or as part of various recipes, making its quality crucial for consumer satisfaction and health. However, milk quality can vary depending on factors like adulteration,

storage conditions, and handling practices during transportation and distribution. Monitoring these parameters in locally sold milk ensures compliance with health standards and preserves its nutritional value.

Physicochemical analyses offer insights into the nutritional attributes and possible contamination or adulteration of milk (Albert et al., 2024; Nyokabi et al., 2021). For instance, fat content affects taste and caloric value, while pH levels can indicate microbial spoilage (Aydogdu et al., 2023; Poghossian et al., 2019). Protein and total solids determine the milk's contribution to dietary requirements and its suitability for dairy processing (Hansen, 1974). Regular assessments not only help maintain product quality but also protect public health by detecting potential hazards.

Previous studies have focused on the quality of ultra-high temperature (UHT) treated milk and raw milk from Modern dairy of Burundi and dairy farms respectively. In addition, the hygiene of the raw milk produced in Burundi was assessed (Albert et al., 2024; Nyokabi et al., 2021). However, no research has been conducted to evaluate the quality of milk sold in local restaurants.

Hence, this study aims to evaluate the physicochemical properties of milk served in local restaurants, focusing on parameters such as pH, fat, protein, lactose, non-fat solids, freezing point, density, and added water. The findings will help in understanding the quality standards of milk in the local restaurants and suggest areas for improvement, ensuring better consumer trust and safety.

2.0 Methods and Material

2.1 Study area

This study was carried out in Bujumbura city located around 3°23'S and 29°22'E. Bujumbura as one of provinces of Burundi, is divided into three communes (as of 2014), which are sub-divided into 13 neighborhoods (per Ministerial Order No. 530/1279 of 22 September 2005). These communes include Muha, Ntahangwa, and Mukaza (Figure 1). Bujumbura is the economic capital, largest city, and main port of Burundi. Bujumbura is on the north-eastern shore of Lake Tanganyika, the second deepest lake in the world after Lake Baikal. The city also lies at the mouth of the Ruzizi River and the smaller Mutimbuzi, Ntahangwa, Muha, and Kanyosha Rivers. From 2023 data, the urban population ranges 1,143,202 and density of 9,000/km² (23,000/sq mi).



Fig 1: Map of Burundi, With Bujumbura city highlighted in red (www.istockphoto.com)

2.2 Study and sample design.

A Cross-section study design and purposeful sampling method were used in selection of area and sample collection. Thirty samples were collected each 250ml and transported to the National Veterinary Laboratory of Burundi, the temperature condition was maintained at 4°C to 8°C in a cool box, and analysis was carried out within 6 to 8 hours after the arrival. This study was carried out from July to October 2024.

2.3 Analysis Equipment

The analysis was carried out by using Lactoscan milk analyzer according to recent studies (Alam et al., 2018; Asefa & Teshome, 2019). The equipment is available at National Veterinary Laboratory of Burundi.

2.4. Methods

Lactoscan milk analyzers were used to analyze all parameters, including density, freezing point, added water, pH, fat, protein, lactose, and non-fat solids. All procedures were carried out in accordance with the manufacturer's manual (Alam et al., 2018; Elzhraa et al., 2021). The device Lactoscan milk analyzer was first cleaned, calibrated, and properly set up. A well-mixed milk sample was brought to the recommended temperature (15–25°C). The analyzer was powered on, and the appropriate testing mode for the milk type was selected. The milk sample was then placed into the device's inlet, where it was automatically processed. The results were displayed on the screen within seconds. After the analysis, the device was cleaned by flushing with a cleaning solution or water to maintain its accuracy and hygiene. Apart from the fact that the devices simultaneously measures multiple components at once, it is also easy to operate and offers quick results, typically within 30 seconds to 1 minute.

2.5. Statistical analysis

The results were recorded in excel and mean and standard deviation was calculated from the results.

3. Results

The mean average of fat; Non-fat solid, pH and added water do not comply with the specified limit while those of Density; freezing Point are within this the specified limit; there's no limit provided for Lactose and protein

Table 1: Mean and standard deviation results of physical chemical properties of milk

Physical Chemical Properties	Mean ± Standard deviation	EAC standard for Heat-Treated Milk EAC 69: 2006
Fat %	2.922 ± 0.863	3.25 minimum
Non Solid Fat %	8.522 ± 0.968	8.5
Density g/ml	1.029 ± 0.004	1.028 to 1.036
Proteins %	3.117 ± 0.359	-
Lactose %	4.676 ± 0.537	-
pH	5.253 ± 0.249	- 6.6 to 6.7
Freezing point °C	-0.5393 ± 0.067	- 0.550 to - 0.525
Added Water %	3.614 ± 6.057	0

4. Discussion

4.1 Fat Content %:

The average fat content of samples collected in this study was 2.922 ± 0.863 , which is less than the criteria of EAC as given in (ISO, 2006). In 30 samples tested, a total of 21 samples which is equal to 70 % were found to have fat content below the minimum level and only 9 samples complied with the EAC standard with the highest values of 4.81 and 4.83. The values are lower in comparison to study conducted in raw milk in Burundi (Albert et al., 2024) and (Nyokabi et al., 2021) which was conducted in Kenya. The low fat content was also found a study of market pouches of milk (Shrestha, 2020). Heat treatment does not affect fat composition rather the composition of milk fat may vary with the stage of lactation, the physiological condition of the animal and seasonal variation of (Dash et al., 2022). The low levels of fat can be explained by adulteration with addition of water.

4.2 pH:

The average pH value of samples in this study is 5.253 ± 0.249 which is slightly low compared to the raw milk which measured 6.67 ± 0.07 (Albert et al., 2024) and 6.76 ± 0.51 of marketed cow milk (Imran et al., 2008). A similar range of pH is observed in the study done in Congo with values of in pasteurized milk ranging from 6 to 6.6 (Bacigale et al., 2023). The decrease in pH is due to protein interaction, which happens when temperature increases during heating (Chandrapala et al., 2010). pH of milk typically ranges from 6.5 to 6.7, influenced by factors such as composition, temperature, and microbial activity. It is crucial for assessing milk quality, and acidification processes caused by microbial activity (Aydogdu et al., 2023).

4.3 Non Fat Solids %.

The average Non-Solid Fat (NFS) was found to be 8.522 ± 0.968 which complies with the EAC standard, the high values of 9.17 and 9.16 were also found in Kenya (Nyokabi et al., 2021). This concludes that the studied milk has a good nutritional profile.

4.4 Proteins and Lactose Content %.

The protein value averaged at 3.117 ± 0.359 and that of Lactose at 4.676 ± 0.537 . There is no stated value of EAC standard. Almost similar values were found in a recent study (Shrestha, 2020) where the protein content ranged from 3.12 to 3.3, and no measurement of lactose was made. Similar findings were also observed in the study by Ecker and Pauw (2020) with the value of protein 3.28 ± 1.02 and that of lactose 4.38 ± 1.36 (Ecker & Pauw, 2024). A study conducted by Albert et al (2024) in three provinces of Burundi has reported the value of protein in raw milk of 4.6 ± 5 which is slightly higher and that of lactose 2.99 ± 4.7 which is slightly lower (Albert et al., 2024).

4.5 Density g/ml:

The average density of all samples in this study was found 1.029 ± 0.004 g/ml that is within the specified standard. The EAC standard specifies the density of milk ranges from 1.028 to 1.036 g/ml. However, 10 samples equal to 33.3% were found to have density below the minimum level. This deviation from this range could indicate impurities or alterations in the milk composition. According to the study of Imran et al., (2008), the density value

was around 1.02 ± 0.02 to 1.07 ± 0.08 which is lower compared to the standard and was due to added water. The results are also comparable to those of the study conducted by Albert et al., (2024) with the density value of 1.031 ± 0.006 which led to the with conclusion that the milk samples were not subjected to any water addition.

4.6 Freezing Point °C.

The average freezing point of the tested samples was found to be -0.5393 ± 0.067 in comparison to the EAC standard, which specifies the freezing point, should range between -0.550 to -0.525 . The general mean complies with the specified value. Similar results are also observed to be -0.592 and -0.576 which is slightly higher (Nyokabi et al., 2021). Despite the average value complying with the standard, slight variations in some samples were observed.

4.7 Added Water %.

The average value of added water of the samples under this study was found 3.614 ± 6.057 %. Water is usually added to increase the quantity of milk for economic purposes. The study reveals that 13 samples were found with added water, which equals to 43.3 % of all samples, with the highest amount of 18.84% and 21.92 %. This type of adulteration was also observed in a study conducted in Kenya which revealed an average value of 2 % (Nyokabi et al., 2021).

Conclusion

While some physio-chemical properties complied with standards, the average fat content of 2.922% was below the acceptable threshold of 3.5%. This undermines the nutritional quality of the milk. The detected average water content of 3.614% confirms adulteration and can be a source of contamination if the quality of added water is not assured. The slightly acidic pH level may also indicate microbial activity due to contamination. This study underscores the critical importance of ongoing monitoring and enforcement in safeguarding consumer health.

The study was limited by financial constraints, as it was self-funded, which restricted access to all restaurants in Bujumbura. Additionally, the research was conducted during a single season, specifically the dry season. For future studies, it would be beneficial to include various provinces of Burundi and cover all seasons of the year to allow for a comparison of seasonal variations

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